WORKING WITH *Plexiglas*

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A Manual for the

SCHOOL SHOP

HOME CRAFTSMAN

OCCUPATIONAL THERAPIST

Published by the makers of Plexiglas

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Plexiglas is a Trade Mark of Rohm & Haas Company

Price $1.50
PRINTED IN U. S. A.

THE HOBBY of working with Plexiglas has an enthusiastic following of people from many walks of life. As a means of recreation it is enjoyed as much by the beginner with a few simple hand tools as by the skilled mechanic with an elaborately equipped shop, for many useful and attractive articles may be made entirely by hand.

Interest in the craft is not limited to hobbyists alone. School administrators, seeing in Plexiglas a material of increasing industrial importance, are establishing special shops in many schools, equipping them to give training in the use of this plastic.

In hospitals and convalescent homes, Plexiglas is used in recreation programs and for occupational therapy. It is ideal for such applications because interesting projects may be found suitable for in-bed, bedside or hospital shop locations.

The widespread use of Plexiglas in home shops started during the war. Over two million members of the air forces and tens of thousands of civilian workers in aircraft plants became acquainted with Plexiglas bomber noses, gun turrets, canopies and other parts of the plane. Many of these people saw in this plastic an intriguing material for homecraft.

Working with Plexiglas is now a popular activity with an enthusiastic following. But workers have frequently expressed a need for more knowledge of the properties and working characteristics of the material. It is hoped this manual may help supply this information. Because the hobby is one that can be enjoyed in the limited working space of the small apartment or dormitory room as well as in the more spacious areas of permanent shops, such considerations as odor, fire hazard or machine noise may be important to some workers. For this reason, these points are included in the discussion of machines or processes.

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WORKING WITH *Plexiglas*

The home craftsman will recognize many outstanding characteristics in Plexiglas—its clarity, strength, light weight and ease of forming, to mention only a few. Plexiglas is a thermoplastic; that is, it softens when heated to a temperature somewhat above the boiling point of water and becomes pliable, so that it can be formed to any shape as if it were rubber. If held in the new shape until cool, it retains that form. If reheated, however, Plexiglas returns to its original shape. This property, often described as "elastic memory" is helpful to the craftsman, since it enables him to salvage for reuse pieces which previously have been heat-formed into other shapes.

The brilliance and transparency of Plexiglas make possible many unusual and beautiful effects, by faceting, edge-lighting and light-piping, and these are described in the section of this manual dealing with design and decoration. In the same section is a discussion of the various dyeing processes used to color clear Plexiglas.

Plexiglas, known chemically as an acrylic polymer, is inert to the action of many chemicals. Mineral acids, strong alkalis and solutions of most common chemicals do not harm it. Kerosene, hexane or white gasoline may be used on Plexiglas with safety. Gasoline commonly available at filling stations contains tetra ethyl lead and must not be used. Aviation gasoline is also injurious, along with such solvents as concentrated alcohol, benzene, acetone, lacquer thinners, carbon tetrachloride and many window cleaning spray compounds.

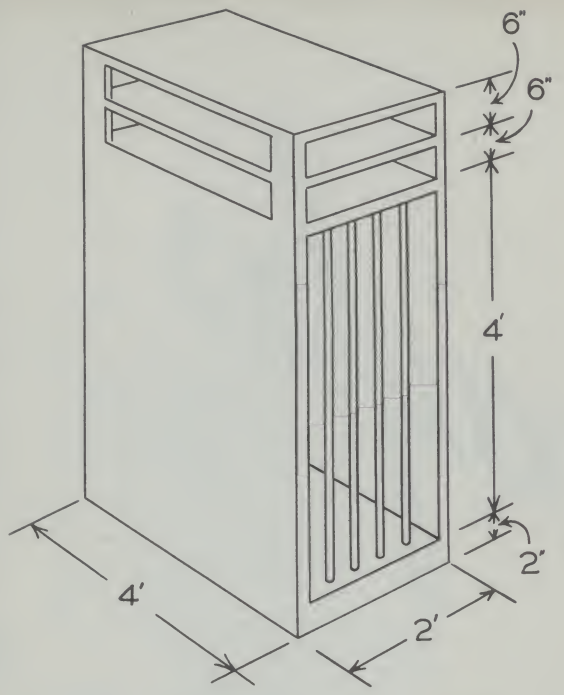
Electrically, Plexiglas is an excellent insulator. It is ideal for school use in high-voltage demonstrations, both as an insulator and as a transparent safety shield. It does not form a "carbon track" under the effect of high voltage discharge across its surface.

The shop worker finds Plexiglas easy to machine with a wide assortment of tools. A few light tools can provide the "table top" fabricator with all the essential facilities for making many articles. More extensive equipment is, of course, needed for the economy of time required in commercial work. Recommended tools, both hand and power type, are described in the discussion of the various processes which would require such tools.

WHAT TO MAKE

Recommended projects for the beginner are those requiring no machine processes, no cementing and no intricate forming operations. Rings, pendants, brooches, bracelets and earrings are favorite items. Photograph frames, lamps, and trinket boxes are also popular.

As the worker develops skill and as he adds to the equipment of his shop, he will find the projects suggest themselves, and soon he will realize the possibilities are almost endless—restricted only by the limit of his own imagination.



PLEXIGLAS STORAGE CABINET

Figure 1

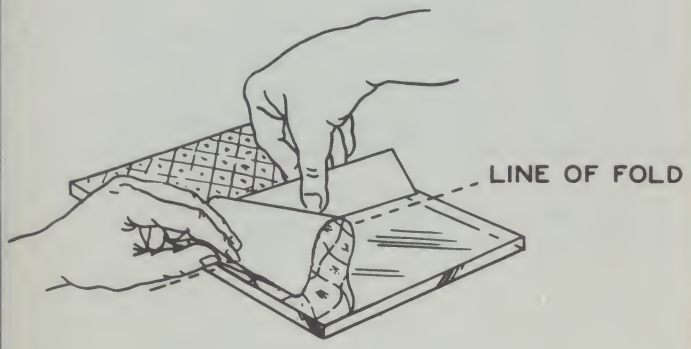


Figure 2

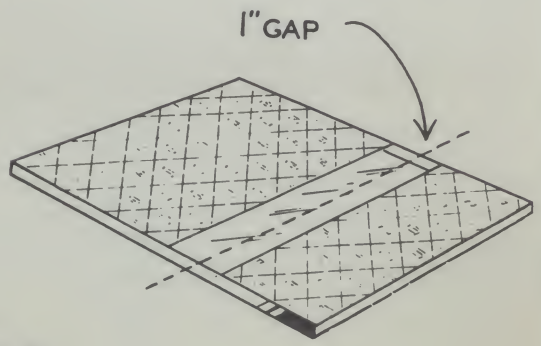


Figure 2a

STORING AND HANDLING PLEXIGLAS

Plexiglas should be stored vertically on edge or kept flat, and fully supported. If it stands at an angle or hangs over an edge, it will warp, and must be laid flat for a time to bring it back to its normal shape.

The home craftsman may have little occasion to stock large-sized sheets, but the school shop no doubt will wish to do so, and should therefore provide proper storage facilities. A bin or storage closet, arranged to keep sheets standing vertically, is recommended. Shelf space for smaller pieces, laid flat, may be provided over the bin. (*See Figure 1.*)

The gummed masking paper covering the Plexiglas sheet should be left in place as long as possible during the fabrication process, since it is easier to avoid scratches than to remove them. It is good practice, however, to peel the paper off sufficiently to examine a sheet before using it. A slow, steady pull removes the paper. It is readily replaced, following inspection, by simply pressing back in place. Warming in an oven a minute softens the adhesive and facilitates removal of the paper.

Prolonged heat or water affects the masking paper, making it difficult to remove. Excessive heat, moreover, may deform the Plexiglas. Oil, alcohol or other liquids which might penetrate the paper should, of course, be avoided. In other words, the material should be stored in a clean, dry place, without too much heat.

It is good practice to mark on the masking paper the thickness and size of each sheet, and not put in storage any piece until it is so marked. Pieces that have been unmasked should be remasked or wrapped in cloth or tissue-paper before storing.

Although the paper may well be left in place during layout, sawing, drilling and edge-finishing operations, it must be removed before heat-forming or cementing is done. Under some circumstances it may be desirable to remove the masking paper from the area that is to be cemented, leaving the balance of the sheet protected. In a similar manner, a portion of the sheet may be unmasked for "strip heating" (see page 20), without removing the rest of the paper. *See Figures 2 and 2a.* Partial unmasking for either of these operations must be carefully done, however, to prevent the cement in the one case, or the heat in the other, from reaching the paper.

Bits of gum from the masking paper sometimes found adhering to the Plexiglas after unmasking may be removed easily by touching with the gummed side of a piece of masking paper. (*See Figure 3.*)

CLEANING PLEXIGLAS

Ordinary dirt can be removed from Plexiglas with soap and water. Use pure soaps—not pumice or scouring types—and do the cleaning with a very soft cloth or preferably just the bare hand. Oil or grease smears that do not wash off can be removed with a little kerosene or *white* gasoline followed by the soapy water. After rinsing, the Plexiglas can be dried by patting with a damp chamois, soft damp cloth or crumpled soft tissue.

Dust particles, held to the Plexiglas surface by static charge, may be blown off or removed by brushing lightly with a damp cloth.*

As a final step in cleaning, or as the last operation in fabricating, the Plexiglas should be given a thin coat of some recommended wax of the Simoniz type. Apply the wax with a damp cloth and polish with clean cotton flannel or jersey.

Waxing increases the surface polish of the Plexiglas and conceals small scratches. It also helps protect the surface against additional scratching. When a Plexiglas article gets dull from dust or soiled by handling, rewaxing will usually restore it to the original finish. Avoid solvent cleaners, Windex, etc.

*"Anti-static" waxes, which carry off accumulated electrostatic charges are available for use on Plexiglas. The effectiveness of these waxes is lost if the surface is washed or wiped with a wet cloth—only dry, soft cloths should be used on surfaces treated with these waxes.

CUTTING AND MACHINING

The steps followed in making a Plexiglas article parallel in many ways those used in metal work. They include layout, machining, forming and joining, as well as, in many cases, various types of finishing operations.

LAYOUT

In most cases a pattern or a folded-up model is recommended when starting to make an article of Plexiglas. The pattern can be transferred to the paper masking the Plexiglas by marking around the pattern or by tracing over it through carbon paper laid on the masking paper. (*Figure 4.*) Free hand sketching or drawing with drafting tools directly on the masking paper is, of course, entirely practical when a pattern is not used.

The pattern may be marked on the surface of the Plexiglas after unmasking by using a wax "china marking" pencil. (*Figure 5.*) Such marks are easily removed by wiping with a soft cloth without marring the Plexiglas surface. A pointed scriber or even a

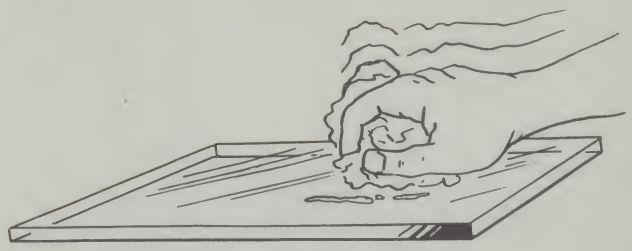
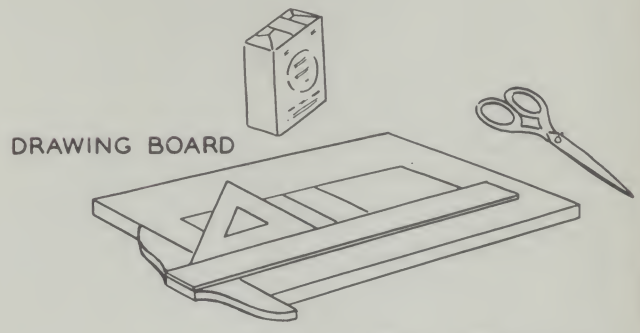
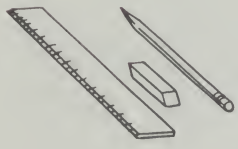


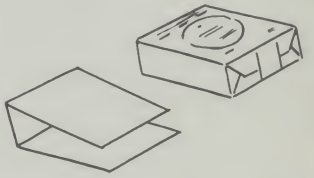
Figure 3

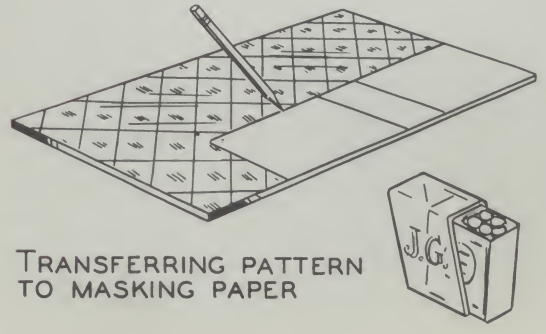


LAYING OUT PATTERN



FOLDING PATTERN FOR SIZE





TRANSFERRING PATTERN TO MASKING PAPER

Figure 4

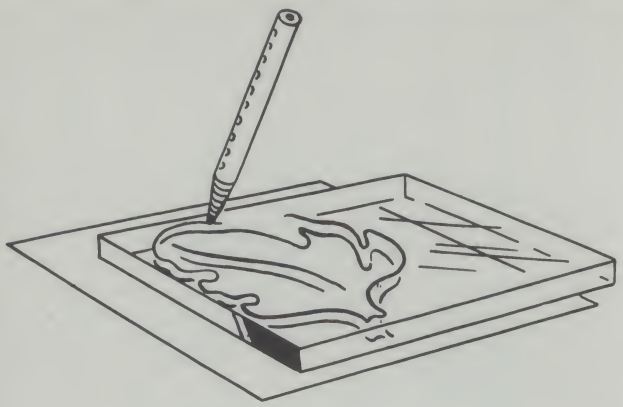


Figure 5

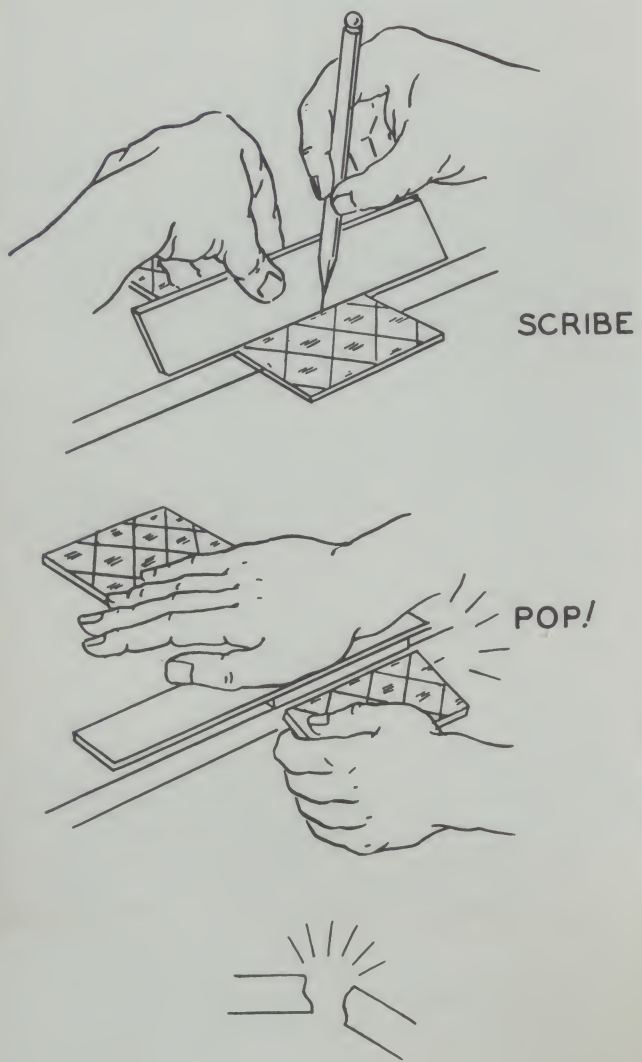


Figure 6

razor blade will do to mark out lines, but, since such tools actually scratch the surface of the Plexiglas, they must be used very carefully. Centers of circles, or points to be joined, can be marked with a light punch-mark or by making a small scribed cross. Holes to be drilled should be center-punched to keep the drill in place.

Fold lines, used in strip heating, should not be scribed, since the scratch offers a starting point for a break. Lines made with china marking pencils are also undesirable because, when heated, such lines may dye the Plexiglas and thereby become permanent. A small mark at either end of the fold is sufficient since, with strip heating, there will be no difficulty keeping the fold straight.

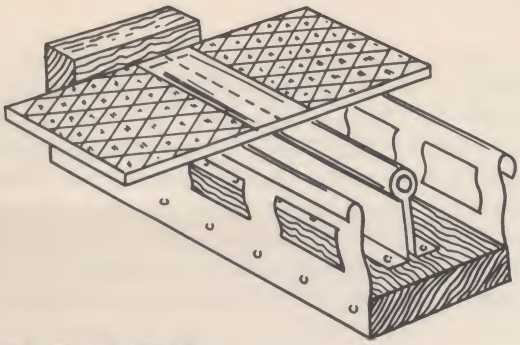
CUTTING

Thin Plexiglas, up to $1/8''$ thick, can be cut by a method similar to that used in cutting window glass. A scribe mark is run across the sheet along a straight edge, making a deep scratch. Then, by holding the Plexiglas rigidly under the straight edge on one side of the mark and pressing the other side down over the edge of a table, the Plexiglas will break along the scratch. The method is not recommended for long breaks or thick material. (*See Figure 6.*)

Hot Plexiglas is rubbery and can be cut like heavy rubber. Hence, for cutting hot Plexiglas, scissors, tin snips, the guillotine-type of paper cutter, or even a heavy knife can be used. (*Figures 7a and 7b.*) Straight cuts are best made by heating the line on a strip heater *(Figure 7)*, leaving the rest of the sheet cold and firm for easier handling. Curved cuts can be made by shears along a scribed line or wax crayon mark, but a margin must be provided for finishing the edge (to avoid the cracking and dyeing difficulties mentioned under "layout), since the edge from scissors cuts is often rough and warped.

Other cutting methods, having less application in the home shop than in the commercial field, include die-cutting and swaging. In die-cutting the heated material is cut out by the sharp edge of a steel die in a press. The operation can be simulated (with difficulty), in the home shop by hammering a sharp-edged shape, like a cookie-cutter, backed with a wood block, through the hot sheet. (*Figure 8.*) Swaging is a process related to die-cutting except the die is a mold in two parts, both of which have sharp edges. The two halves, with the hot Plexiglas between, are brought together in a vice or clamp and held until cold. Blanks for small parts such as earrings, buttons, pendants and the like are cut out and formed in one operation by this means. (*Figure 9.*)

There is still another method of cutting Plexiglas, little used, but entirely practical under some circumstances. This is hot wire cutting, and consists of pressing the sheet edge against a wire or thin blade heated to a point just under red heat. A set-up for



STRIP HEATER

HEATING PORTION OF SHEET

Figure 7

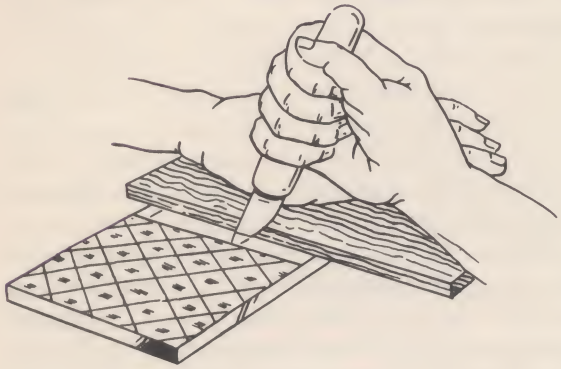


Figure 7a

GUILLOTINE CUTTING
OF HOT PLEXIGLAS

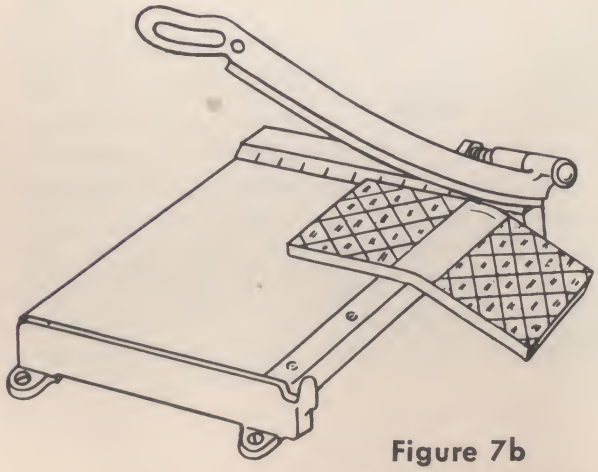


Figure 7b

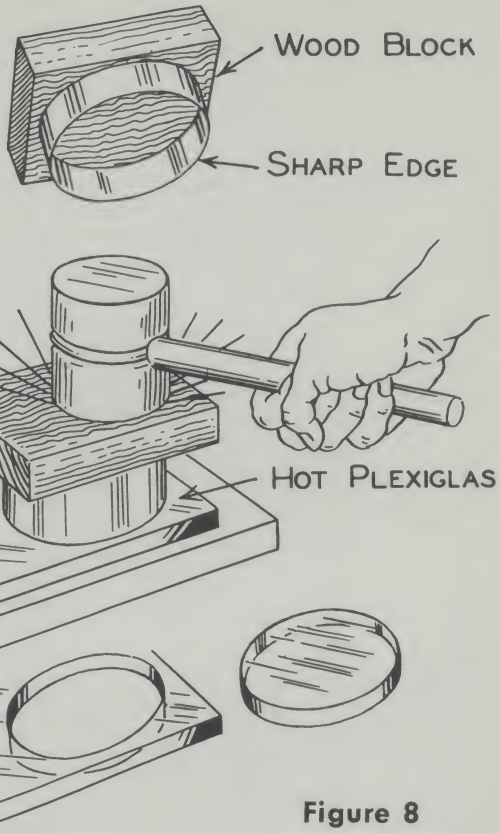


Figure 8

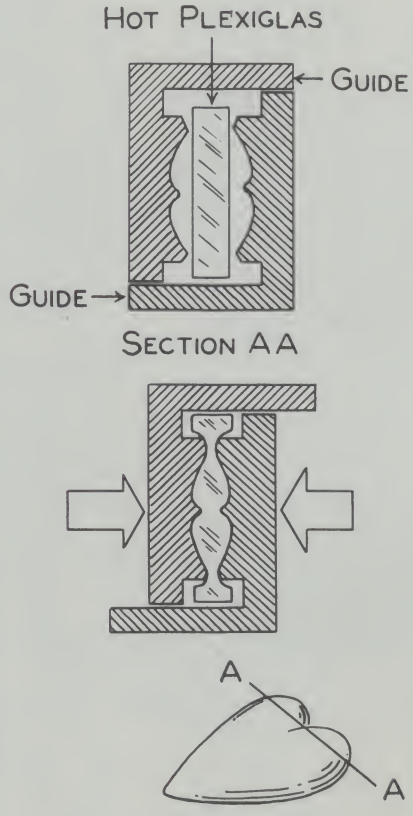


Figure 9

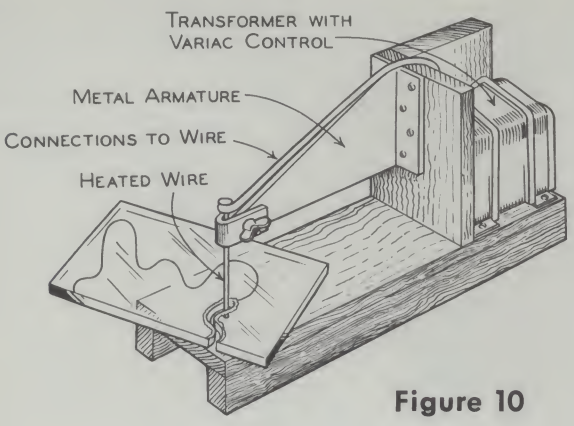


Figure 10

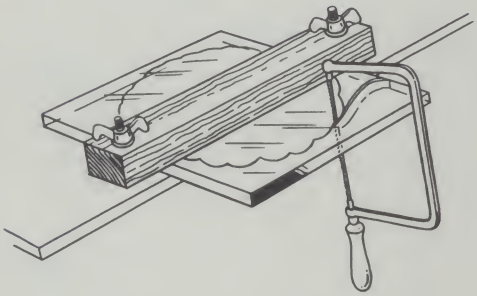


Figure 11

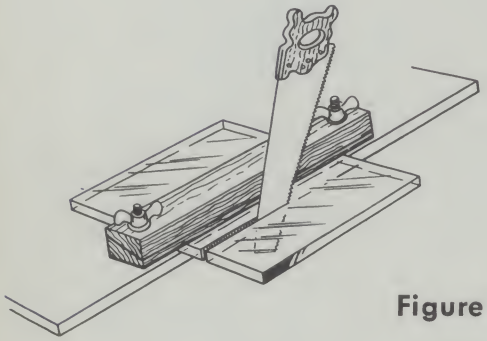


Figure 12

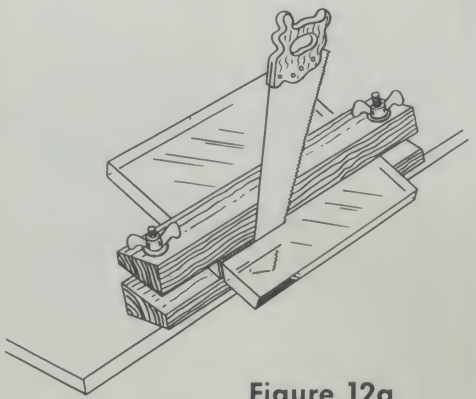


Figure 12a

hot-wire cutting, with the wire heated by its own resistance in an electrical circuit, is illustrated in *Figure 10.* The method works well, particularly on thin material, but it leaves a rough edge requiring finishing. The temperature is rather critical; the wire should be near red-heat to cut well, but only a few degrees increase from this temperature will cause the Plexiglas to smoke. At proper temperature, however, this method is neither dangerous nor unpleasant.

SAWING

Plexiglas may be sawed with any type of wood or metal-cutting saw, either hand or power operated. Of the many kinds of hand saws available the hollow-ground straight saw and the deep-throat coping saw are usually found most useful, although compass saws, hack saws and various other types of hand saws may also be used. A straight saw having eight to ten teeth per inch with very little set is recommended. The saw should be used with little pressure and it should be kept straight, since if the saw binds the Plexiglas may be cracked. Straight hand saws should be held at an angle of about 45° from the vertical, to engage two or more saw teeth in the material at one time. In the case of the coping or scroll saw, very narrow blades usually give best results. When scroll-sawing a curve or silhouette, care should be taken to keep the edge of the material supported to lessen the danger of cracking the plastic.

Clamps, jigs and miter boxes are very helpful—almost essential—accessories in hand-sawing Plexiglas. A simple but very useful clamp is made by bolting a straight wooden bar on the table top, arranged so that the Plexiglas can be slipped under it and held by tightening the bolts. (*Figure 11.*)

More complicated clamps, designed to hold work vertically or at an angle, as well as horizontally, will be found helpful in many operations. A suggested design is shown in Figures 12, 12a and 12b.

POWER SAWS

The three outstanding types of power saws are jig-saws, band saws and circular (table or variety) saws. Each of these tools has a wide range of usefulness in working Plexiglas, as will be evident from the descriptions following.

JIG SAW

Fundamentally, the jig saw is merely a power-driven coping saw. It saws with a short, thin blade that is driven rapidly up and down through a hole in the center of the saw table top. Although foot-powered models of jig saws are often used and are entirely practical, the most common type is driven by an elec-

tric motor, as indicated in Figure 13. Jig saws are excellent for interior cuts, since the blades may be readily removed, passed through a hole in the plastic to start the cut, and then replaced. Jig saw blades, being very narrow, are excellent for cutting complicated profiles.

The jig saw is the slowest and least dangerous of the power saws. It is economical to operate, for although blades break frequently, they are cheap and easily replaced. As to noise, the jig saw makes a simple thumping noise, which is not usually objectionable.

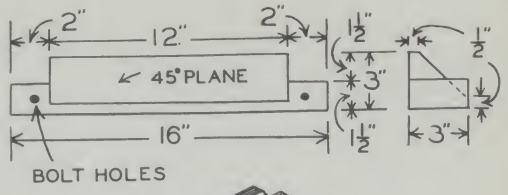
Attachments are available for jig saws which enable the machines to do filing. These attachments are invaluable for small-scale work. For example, a triangular file, driven by the jig saw, is a practical means of putting notches in a pattern. (See the leaf form in Figure 14.)

BAND SAWS

The band saw, used for either curved or straight sawing, is a flexible steel band with teeth along one edge. It runs on two wheels or pulleys, one set above the other, power being applied to one to drive the band around. (*See Figure 15.*) The distance between the wheels may be adjusted to provide the required tension for the saw. In use, the work rests on an adjustable table through which the saw passes. The diameter of the wheels carrying the saw is, of course, the capacity of the machine. For instance, a 10″ saw (one with 10″ wheels), can saw only to the center of a 20″ circle.

The band saw is as versatile as the jig saw except for the fact, that, because of the continuous blade, it cannot be used for cuts starting from the inside of holes. It is not difficult to operate, and intricate designs can be cut, curves of very small radius being possible when extra narrow blades are used. A good blade for general use on a 10″ saw is one ⅜″ wide with ten teeth per inch. For sawing thick Plexiglas a blade with about four teeth per inch, followed by a gap to help clear the cut of saw dust, is good.

To avoid breaking the blade, do not feed faster than the blade cuts but use only slight pressure. To avoid binding, especially on sharp curves, the material is eased back from time to time from the cutting edge. The edges produced by band sawing are rather rough and require considerable finishing. Too much pressure or turning the material too quickly in curved cuts is the common cause of blade breakage in band saws. Broken blades are mended by butt welding or brazing —a service commonly available where saws are sharpened, as well as in most welding shops. Extra blades should be kept on hand.



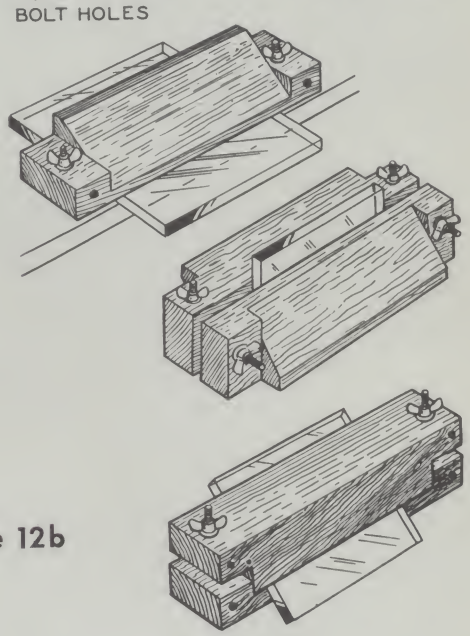


Figure 12b

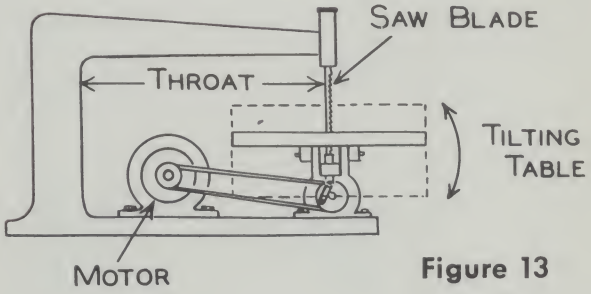


Figure 13

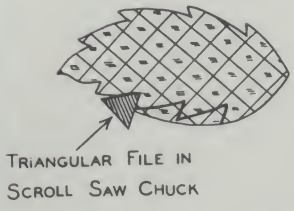


Figure 14

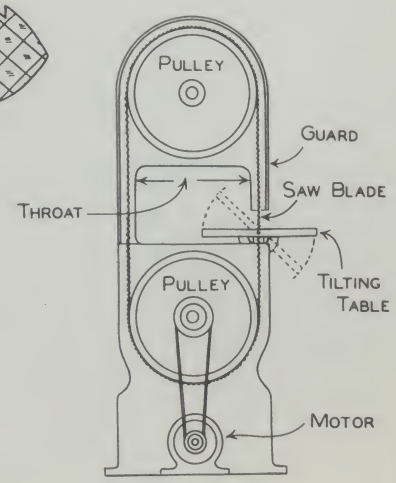


Figure 15

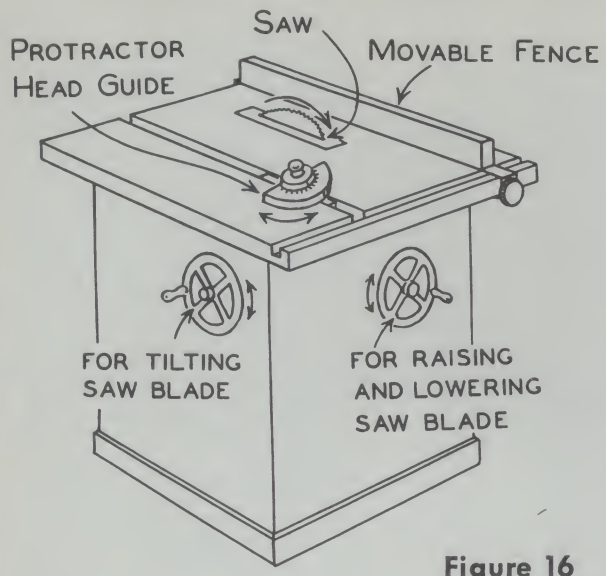


Figure 16

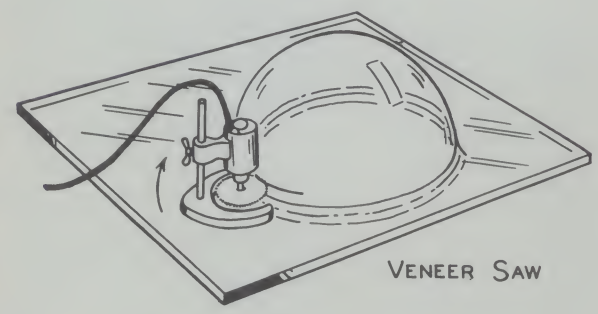


Figure 17

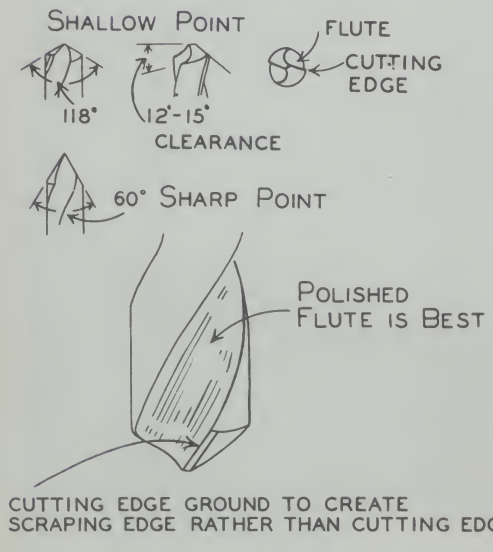


Figure 18

The band saw is not particularly dangerous, although since it cuts much faster than the jig saw, careless operation may lead to injury. The noise of a band saw is generally not offensive.

If a shop has a table or bench saw and jig saw, the band saw can be omitted, but the speed, together with the versatility of the band saw, makes it a most popular tool in any shop.

Sanding belts can be used on many band saws by changing the saw guides, and are very helpful in sanding curved edges.

TABLE OR BENCH SAWS

The table saw is a small circular saw revolving in a slot on a table. Adjustments make it possible to raise or lower the blade, with respect to the table, and to tilt the blade or table to cut angles. An adjustable "fence" guides material for straight cuts and a "miter gage" serves the same purpose for cross and angle cuts.

For Plexiglas, a hollow ground blade with no set and having seven to ten teeth per inch is good. A coarser blade is preferable but not necessary for heavy material. The diameter of blade used will depend on the design of the saw frame, but seven to ten inch blades are satisfactory. Heavy material may be cut with small saws, by making successively deeper cuts, increasing the depth about one-half inch each time.

The cut made by a good table saw is quite smooth and requires a minimum of finishing if the saw is kept sharp. Tallow applied to the blade helps produce a still smoother cut.

The bench saws, even in small sizes, make a rather loud whining noise which, in some places, may prove objectionable. They are also more dangerous than jig or band saws. A fundamental rule of safety for operating bench saws is that work never be pushed past the saw by hand. A "pusher," a conveniently shaped notched stick, should be kept at hand for this purpose.

Attachments for the table saw include dado heads and other molding cutters and sanding pads for disc sanding. In the production fabricating shop the table saw is essential. For the amateur, however, if a jig or band saw is available, the table saw is a convenience rather than a necessity. It is an invaluable saw for cutting wood for jigs. (*See Figure 16.*)

MISCELLANEOUS POWER SAWS

The jig, hand and bench saws cover the types of power saws commonly found in small shops. There are several other types that are useful, chiefly in production operations. Small veneer-cutting saws, consisting

of motor-driven circular blades 4" in diameter or less, mounted in a base that slides over a flat surface, are particularly useful for trimming three-dimensional formed Plexiglas parts. (*See Figure 17.*)

PUNCHING AND DRILLING PLEXIGLAS

Holes in Plexiglas are made by punching or drilling. In the home shop punching does not have wide application. Small holes in cold Plexiglas may be punched with a hot needle, withdrawing it before it cools.

An adaptation of this "hot-wire punching" is used in inserting small screws or fasteners in Plexiglas. The metal fastener is merely heated and pushed into place in the Plexiglas. As it cools it "freezes" in place quite firmly.

For regular drilling, ordinary twist drills can be used but the shape of the cutting point should be modified for best results. Drills for use in Plexiglas should be ground as for work in brass—so they scrape rather than cut. Grinding the rake from the cutting edge accomplishes this purpose. Clearance should be allowed between the cutting and the drilling edges. (*See Figure 18.*) The usual 120° angle, ground for scraping action is good, or the angle may be reduced to 60°, producing a sharp pointed drill that is preferred by some craftsmen.

For the best possible finish in a hole the drill should have polished, slow, spiral flutes. These enable the drill to clear the hole of shavings and leave a good finish on the walls of the hole. The flutes should be wide enough to clear the widest chip the cutting edge can produce. Fuzzy or irregular finish is caused by the shavings rubbing on the walls of the hole, melting and smearing or "burning" the walls.

Drill bits may be driven by such hand devices as the brace or breast drill or by power tools. Hand drills work quite well, but the Plexiglas should be firmly supported and the drill should not be allowed to break through from excessive pressure as it nears the opposite side of the sheet. Water, kerosene or oil may be used as a lubricant if there is a tendency for the friction heat to "burn" the sides of the hole. Small drills such as jewelers use, or the drills designed for cleaning tips on welding torches, may be used, rotated by hand, for button or bead holes.

For power drilling, motor-driven flexible shafts, hand-held motor "drill guns" (*Figure 19*) and table or floor mounted drill presses (*Figure 19a*) are most commonly used. The flexible shaft or portable hand drill is particularly helpful where it is difficult to maneuver the Plexiglas on the table of a drill press. Any of these devices may be used in the process of "interior carving."

Attachments such as buffers, sanding discs, sanding spindles and the like may be fitted in the chucks of any of these drill tools.

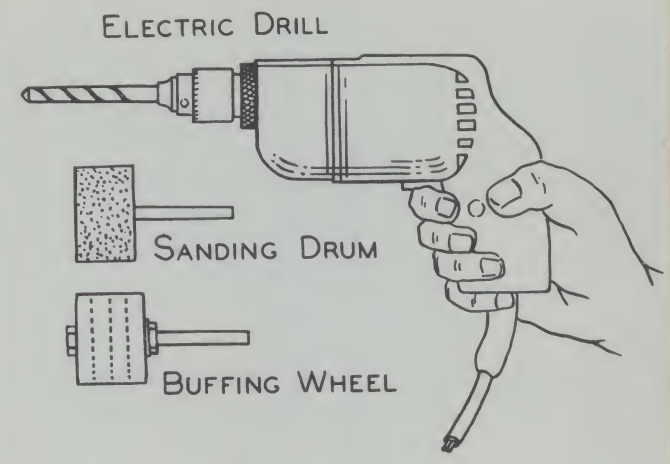


Figure 19

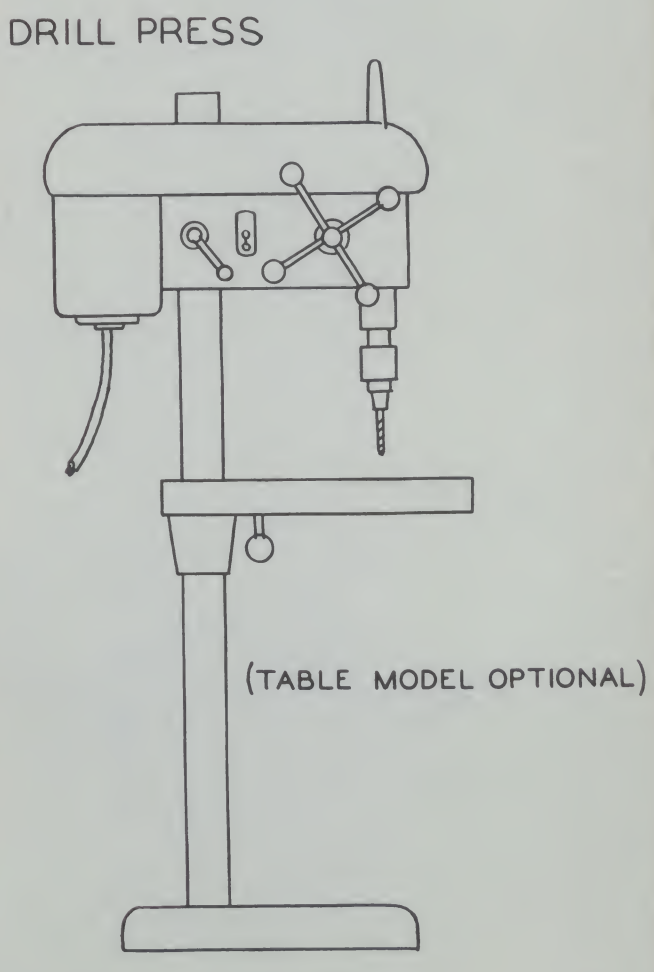


Figure 19a

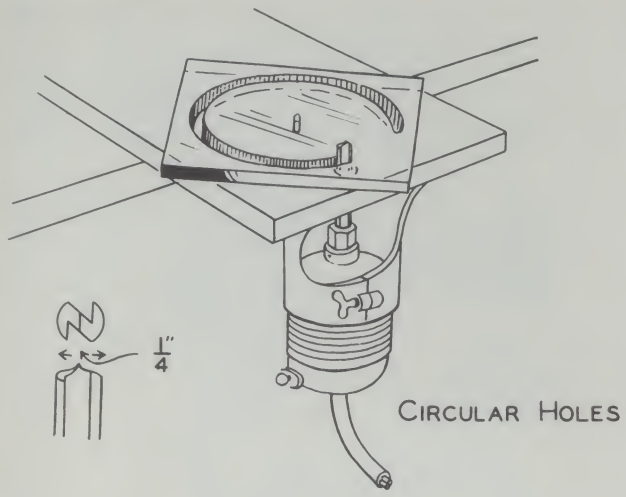


Figure 20

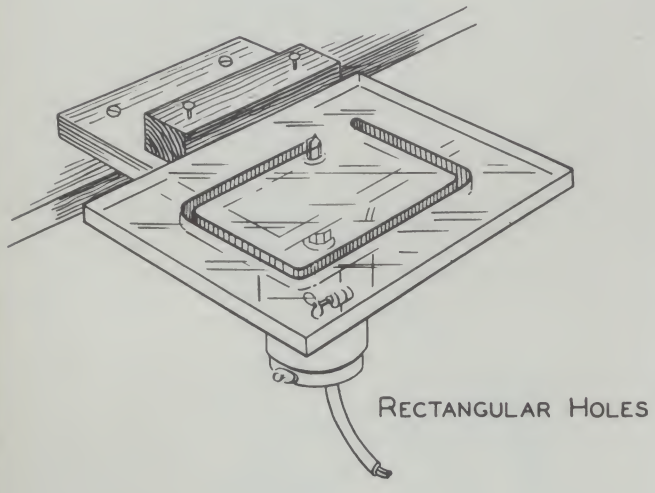


Figure 20a

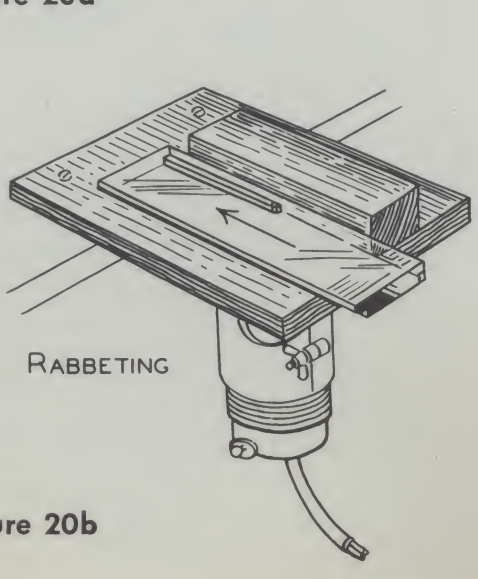


Figure 20b

The drill press is commonly a quiet tool. Portable drills, on the other hand, have a characteristic, high-pitched, siren-like sound which, although not excessively loud, might be unpleasant in some cases. There are no unusual safety hazards involved in the operation of the various types of power drills.

ROUTING AND SHAPING

Routing and shaping are related operations involving removal of material by the action of a whirling cutter. The cutters may be either straight-fluted or shaped in a profile, as the job may require.

The portable hand router and the small table router are very useful tools. In some designs the small table router becomes a portable router by releasing the clamp holding it in place. In addition to cutting patterns on the edge of a Plexiglas part, routers are very useful for cutting out large holes in the sheet. Figure 20 illustrates how a circular hole can be cut. A small hole is drilled in the center of the Plexiglas to be removed. A nail or peg is placed in the router table at a distance from the cutter equal to the radius of the hole to be cut. The Plexiglas sheet is then placed on the router table so that the hole fits over the peg. The router cutter is raised above the table far enough to pierce the upper surface of the Plexiglas and the plastic is revolved around the nail as the router cuts out the circle. To avoid slipping when the circle cuts out, it is good practice to leave a narrow neck to be cut out by hand. Figures 20a and 20b illustrate other applications for the router.

Routers and shapers can be very dangerous tools and should be operated with due caution. The noise is a high-pitched whine, similar to that of the portable drill.

TURNING

Plexiglas can be turned on either wood or metal turning lathes. The metal turning type, commonly known as the engine lathe, is preferred because of its rigidity and the wide range of operations which can be performed with it. Sizes of lathes vary from the tiny precision lathe used by jewelers to enormous floor models used for large machining operations. The home craftsman will find a 9 or 10 inch bench lathe satisfactory for ordinary requirements in turning Plexiglas.

Satisfactory operation of an engine lathe requires considerable skill and experience and will not be discussed in detail in these pages. Various manufacturers of lathes have excellent manuals describing the operation of their machines and the home craftsman will have no difficulty securing such booklets.

In general, the recommended procedure for turning Plexiglas is about the same as that used in working with brass.

The lathe is the only practical means of producing most turned parts. Knobs, furniture legs, vases, lenses —all such circular parts call for lathe work. In addition, the ingenious home craftsman will find many other operations for which the lathe can be used. The machine is not dangerous and it is not particularly noisy.

FINISHING OPERATIONS

Finishing, as applied to Plexiglas, refers to any of the processes used to bring surfaces to a high polish. It includes such operations as filing, scraping, sanding, ashing and buffing, all of which are described here. Some of the processes, notably filing and scraping are also used at times in shaping Plexiglas, but the major application is in finishing.

FILING

Plexiglas files easily and can be brought to a surface ready for the final polishing by filing alone if the job is correctly done. For filing edges to remove tool marks, a 10 to 12 inch smooth-cut flat file is recommended. Filing should be done in one direction, keeping the file flat on the surface of the material, but at an angle with the direction of motion that will prevent grooving of the Plexiglas by the file teeth. (*See Figure 21.*) To keep the file in good condition it should be cleaned frequently, using a wire or fiber file brush. Files used in working Plexiglas should not be used for filing metal or other materials that would dull or gum the teeth.

Half-round or rat-tail files are useful for smoothing the inner surface of holes. A triangular file is useful for notches or grooves. A set of very small files is excellent for finishing fine scroll work. Files that can be inserted in a jig saw will prove very useful for shaping, cutting or finishing a profile. *(See Figure 22.)*

A padded vise, jig or clamp is almost necessary to hold the work while filing is done. For very small work it is often easier to clamp the file in the vise and rub the piece across it (*Figure 23*). In other cases, a hand clamping device, such as a padded "pin" clamp or a ring clamp, such as is illustrated in Figure 24 is helpful.

For "wet filing" thin oil is preferable to water, since water rusts the file.

SCRAPING

Scrapers are as useful to the Plexiglas craftsman as to the cabinet-maker. A typical scraper is a piece of thin hard steel, perhaps 3 inches square, with a sharp, square-cut edge, neither burred nor rounded. Since the tool is so simple, it may, obviously, be made in many other forms. A piece of saw blade, a ground-down file edge, the back of a knife blade—any piece of thin hard steel may serve. Shaped scrapers, to fit a contour, are also practical.

Scrapers may be sharpened on the grinder or by whetstone or file. The essential requirement is to keep the edge straight and square. The practice of burring a scraper edge, common in wood-working, is not recommended for working Plexiglas.

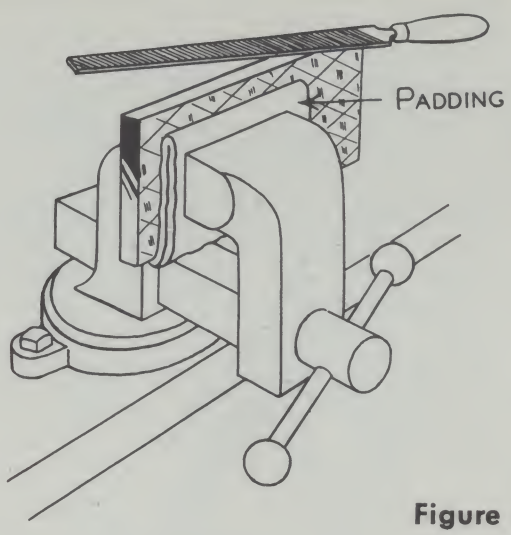


Figure 21

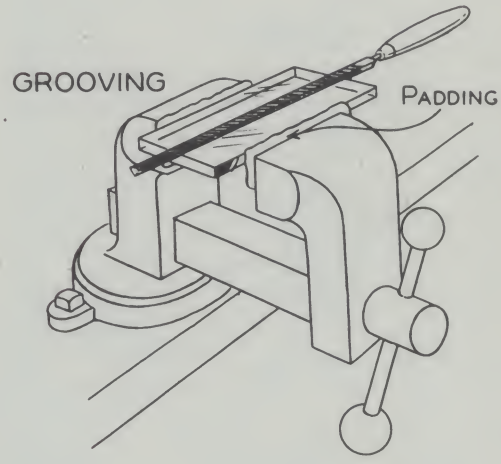


Figure 22

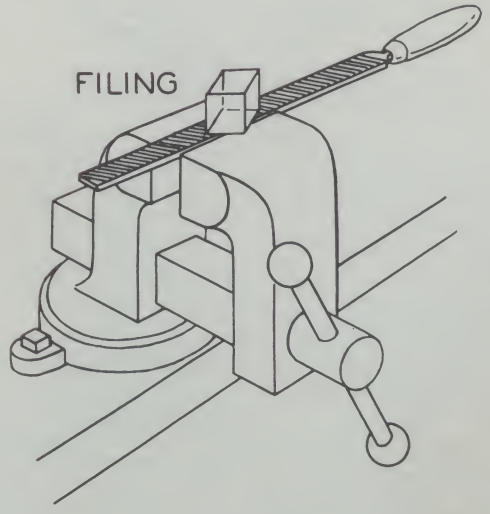


Figure 23

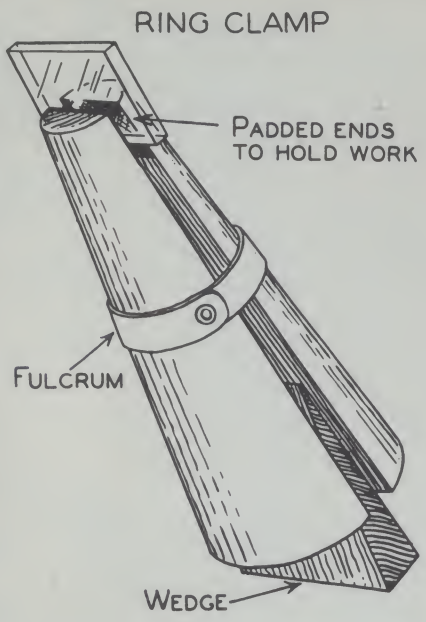


Figure 24

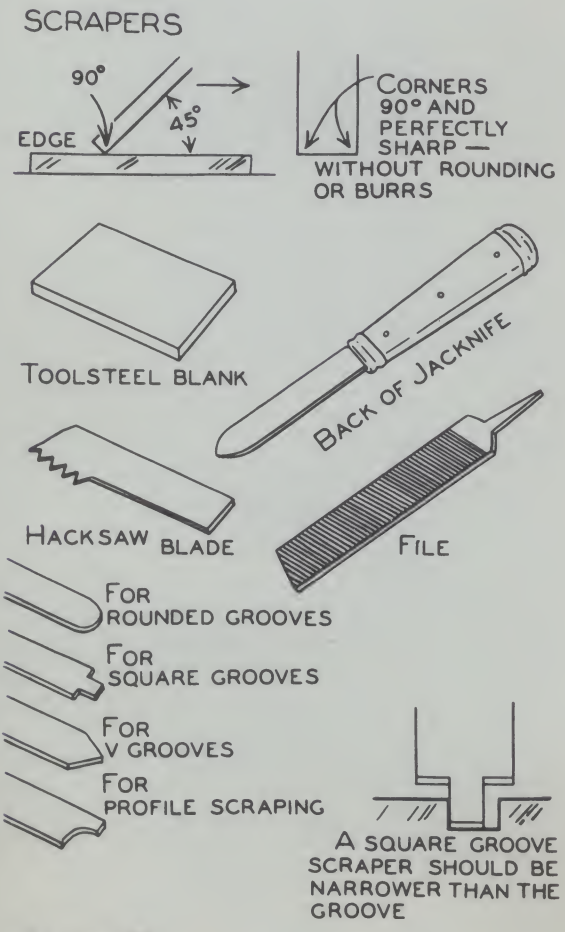


Figure 25

In use, the scraper is held at an angle of about 45° and drawn across the Plexiglas. The sharp right angled edge removes a thin shaving, leaving a smooth surface ready for polishing. Repeated strokes of the scraper will, of course, continue to remove material, so that it is possible, although tedious, to shape a Plexiglas part, as well as to prepare it for polishing, with the scraper. Figure 25 illustrates a few typical applications for scrapers.

A scraped edge that shows waves or "riffles" indicates vibration of the work in the clamp. Shifting the direction of scraping will remedy the condition.

SANDING

Sanding is commonly the last step in finishing before the buffing operation. There are a number of power sanding devices, which will be described, but the home craftsman will probably find that for his purposes sanding is still largely a hand operation—tedious but very essential for a well finished article.

Although the technique for sanding Plexiglas is not essentially different from that used in woodworking, the surface desired in a Plexiglas article is usually such that the sanding must be far more carefully done. A detailed account of the process, therefore, is supplied.

For most work "wet-or-dry" sandpaper, used wet, is recommended for work on Plexiglas. Beginning with a relatively coarse paper (about 240 to 300 grit) the work is sanded until all scratches except those caused by the sand paper itself are removed. Keep the Plexiglas wet during all the sanding operations but wipe it dry to inspect the progress of the work. After the work with the first paper, shift to a finer grit—perhaps 320 or 400—and, if the nature of the piece will permit it, sand across the scratches left by the first sanding. When all of the marks left by the first paper are removed, change to a still finer grade of paper, change direction again, and repeat the operation. Observation and experience will help determine just how many different grades of paper to use for the most efficient work. The final paper (600 grit) should leave the work satin smooth and ready for easy buffing to a high polish.

In hand sanding of small parts it is often easier to fix the sandpaper and rub the Plexiglas across it. The craftsman may find various ways to do this. One practical method is to fasten the sandpaper to a sheet of plate glass with rubber bands. (Glass is recommended because it is flat and is not affected by water.) A piece of glass about 12″ x 19″ is recommended since this size permits four sheets of paper (giving four different grits), to be fastened to it. Two sheets are placed on each side of the glass, fastened with three rubber bands. (*See Figure 26.*)

Strips of sandpaper, wrapped around a wooden dowel or a twist drill, serve to sand holes or fine scroll work. Small pieces of paper on a cloth pad or used with finger pressure alone are used for small curved areas.

Dry sandpaper may be used in hand sanding, but for most applications is less satisfactory than the wet paper. Strips of dry paper, pulled back and forth like a shoe polishing cloth, are sometimes used to round the edge of Plexiglas.

For either wet or dry sanding, where large areas are involved, a sanding block should be used. It is easily made from a piece of wood with the edges rounded to avoid breaking the sandpaper, the size being such as will fit the hand comfortably.

MACHINE SANDING

A number of power-driven sanding devices are available and any of them may be found useful for work on Plexiglas. The disc sander and the belt sander are particularly useful.

The disc sander is just what the name implies—a disc of sandpaper on a flat, circular backing plate, rotating on the end of a power-driven shaft. A table, preferably adjustable, is fitted in front of the disc to support the work.

Disc sanders are available as complete units, or as attachments for other machines, such as grinders, circular saws or lathes. Many craftsmen make their own disc sanders, sometimes attaching them direct to a motor shaft. The sanding disc varies in size with the equipment available, 8 or 10-inch discs being common sizes. For production work, larger discs—12 inches or more—are recommended. Special resin is used for attaching the sanding disc to its backing plate, to permit easy removal when a change of grit is desired.

Disc sanders are more valuable for machining operations than for finishing parts already machined. Small objects can be quickly beveled or otherwise shaped with disc sanders, using no other power tools at all. (*Figure 27.*) By rotating the Plexiglas in the hand as it is being sanded, curved sections are easily formed.

Work held against a sanding disc should be moved back and forth along the radius of the wheel and, when possible, turned end for end at intervals in order to secure even results. The sanding action of a disc sander naturally increases as the distance from the center becomes greater, due to the increase in surface speed. Care is necessary, therefore, especially when sanding work several inches long, to avoid producing a wedge-like effect.

Disc sanders are not particularly dangerous and are generally not objectionably noisy. They do produce a lot of dirt (a combination of Plexiglas particles and sanding grit), and are not practical in "table-top"

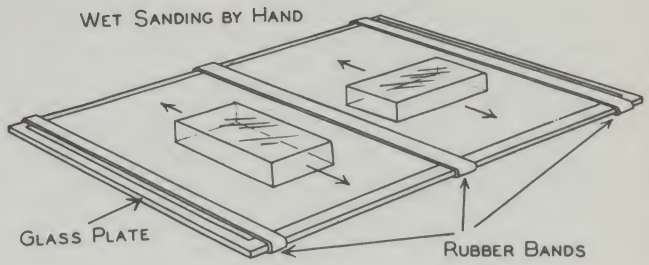
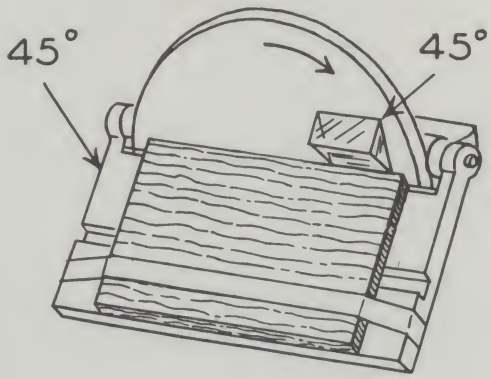
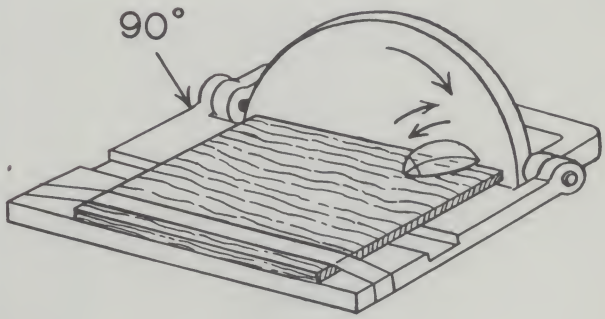


Figure 26





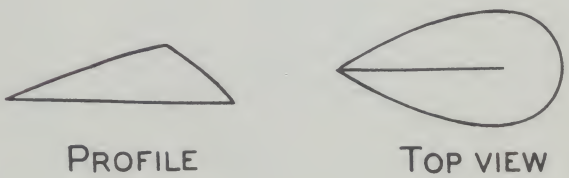
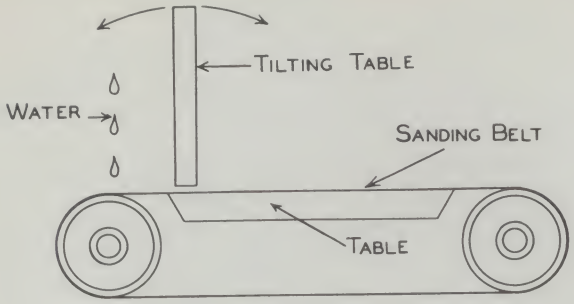


Figure 27



BELT SANDER

Figure 28

VERTICAL BELT SANDER

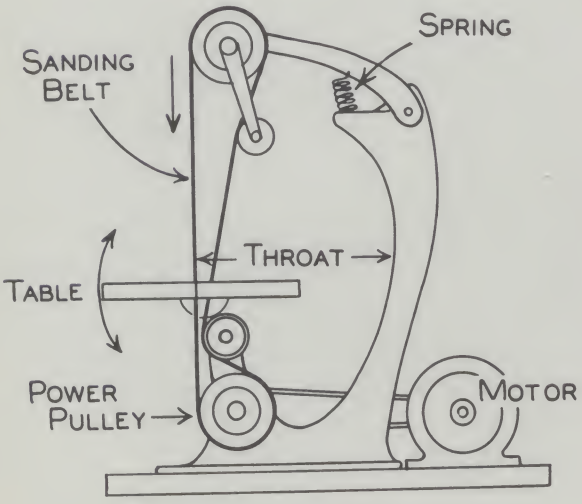


Figure 28a

STITCHED COTTON BUFF FOR ASHING

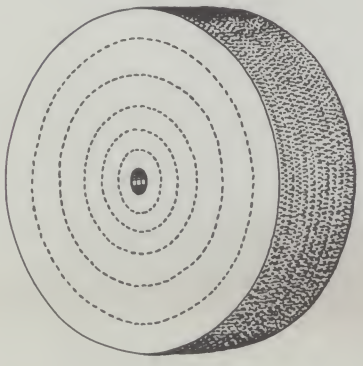


Figure 29

shops unless suction boxes are provided to control the dust. Because the water throws from the wheel excessively, wet sanding is seldom attempted on disc sanders.

BELT SANDERS

The belt sander, because it can be used wet, is very helpful for finishing operations. Variations of design in belt sanders are many (*Figures 28 and 28a*), but the fundamental characteristic is merely an endless belt of sandpaper revolving over two rollers, one of which supplies the power. The home craftsman often finds a belt 12 to 18 inches between centers and about 3 inches wide satisfactory.

Wet sanding machines are commercially available or a regular dry sanding machine can be modified by the addition of a punched can to drip water on the belt. Splash guards at the ends of the belt, and a drip pan underneath, should be provided.

The belt sander is excellent for sanding flat surfaces. By using the rollers at the end, various curves may also be sanded. It is not a dangerous machine and is not noisy. It is not quite as objectionable as the disc sander in the matter of dust produced, but it is still essentially a shop machine.

The home craftsman can readily acquaint himself with the various other types of sanders, but he will probably find the two just described most useful for his needs. Power-driven vibrating or rotating pad sanders are coming into increasingly widespread use in production shops, but are not particularly valuable in the small hobby shop.

ASHING AND OTHER FINISHING

Ashing is the process of buffing an object on a rag wheel Figure 29 with abrasive, such as pumice, and water. A very fine satiny finish is produced, even in the grooves and depressions of the object, and very little final polishing is required to secure a fine, high polish. A disadvantage in ashing is found in the fact that it is difficult to keep sharp edges and corners—important elements in design for brilliance—from being rounded off by the abrasive buff.

The ashing operation, moreover, throws wet pumice on the operator and around the shop, even with carefully designed guards, and it is, therefore, a rather messy process.

BUFFING

Following the machining and finishing operations, Plexiglas is brought to a high polish by buffing. Hand buffing, using dry Bon Ami or *very* fine abrasive on a cotton flannel cloth is entirely possible, and a fine polish can be obtained, but the process is very tedious. Power-driven buffing wheels are recommended for even the small shop. (*See Figure 29a.*)

A number of types of buffing wheels have been used

successfully in polishing Plexiglas. Experience shows a very satisfactory buff consists of layers of 3/16" carbonized felt. Enough layers should be laid together to build the thickness up to about 3 inches. The diameter of the wheel is, of course, regulated by the conditions of the individual shop. A wheel as large as 15" in diameter is excellent, but much smaller buffs will give good results. A metal or wooden collar with a diameter about 1 1/2" less than that of the felt is placed on each side of the felt disks and the whole bolted securely before being placed on the arbor or shaft. (*See Figure 29b.*) The wheel should run at a speed of 1800 feet per minute, surface speed. (Note that the reference is to *surface* speed, not revolutions). A speed as low as 1200 feet per minute can be used. A mixture of tallow and whiting on the wheel makes a good buffing compound. Tallow and tallow base buffing compounds suitable for this use are available commercially.

To use the buff, first touch the wheel with the tallow stick, and then, more briefly, with the buffing compound. Then hold the Plexiglas lightly against the wheel, and, keeping it in constant motion, pass it back and forth on the wheel until it has been uniformly polished. The felt wheel shows little tendency to "burn" the Plexiglas as long as there is enough tallow on the wheel to act as a lubricant.

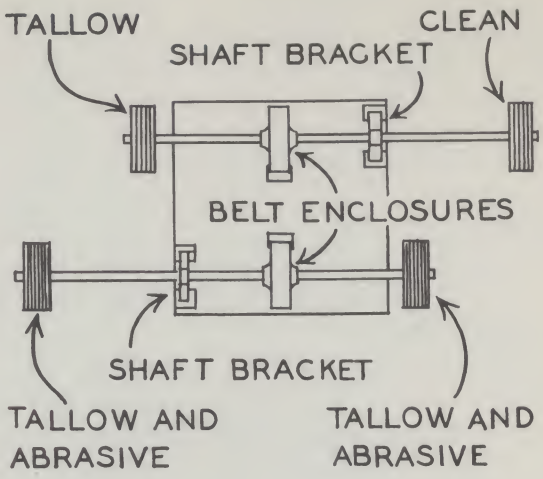
Burning is a surface defect produced when under the frictional heat of buffing the rotation of the buff actually moves some material from one point on the surface to an adjacent one. It results when buffing is continued too long in one spot or when too much pressure is used.

By using the sharp felt edge of the buffing wheel, 90° interior angles can be polished. By skillfully reducing the pressure as the buffing proceeds, it is possible to produce the final polish on the one wheel, although many workers use two or more wheels, finishing on a clean cotton buff with either tallow or compound. This final clean-off buff should be loose and soft and can run at a higher speed than the felt buff.

Either buffing or clean-off wheels may be cleaned of hardened tallow and abrasive by holding the teeth of a hacksaw blade against the rotating wheel. Use care. The buff may catch the blade and throw it with considerable force if the teeth are not properly directed.

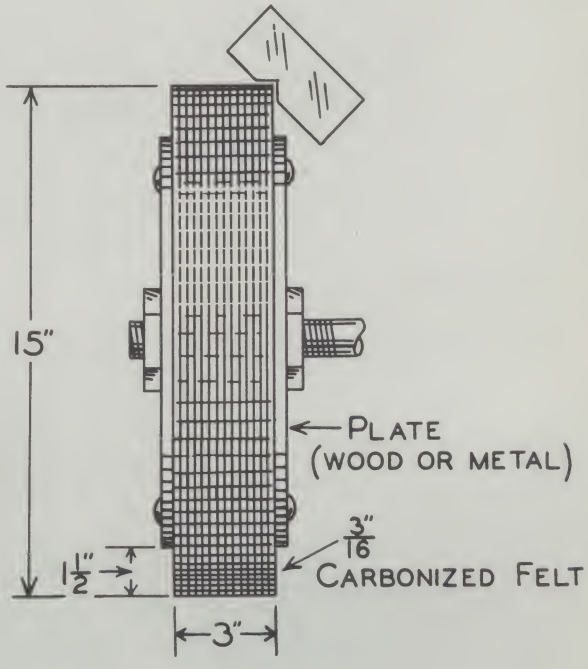
The heat generated by buffing operations may set up stresses in the Plexiglas surface which could result later in "crazing"—a surface condition somewhat resembling "checking" in a varnish finish. Annealing removes this danger and is recommended especially when extensive buffing has been required. Annealing consists simply of heating the object to about 120°F. and for several hours, cooling it gradually after the heating period.

Other polishing methods, such as flame polishing or polishing by solvent action, increase the crazing tendencies so greatly that they cannot be recommended.



NOTE: BUFFING WHEELS ARE STAGGERED IN POSITION SO THAT ABRASIVE OR TALLOW WILL NOT FLY ONTO CLEAN WHEELS.

Figure 29a



BUFFING WHEEL

Figure 29b

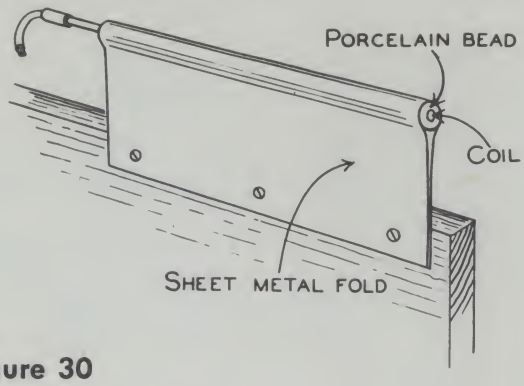


Figure 30

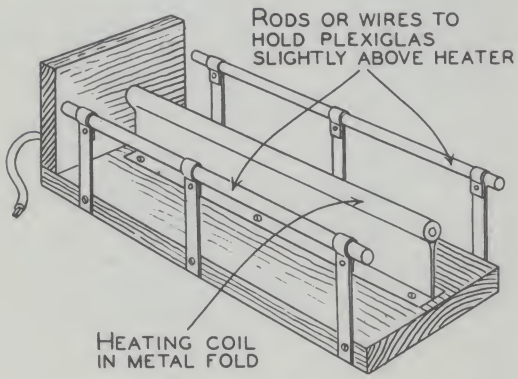


Figure 30a

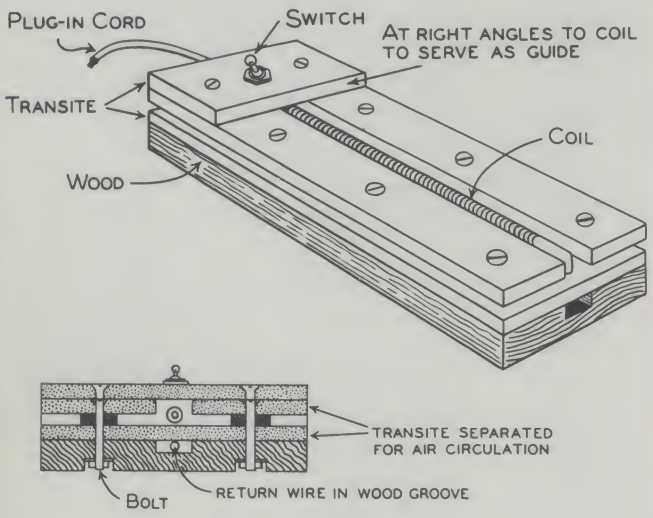


Figure 30b

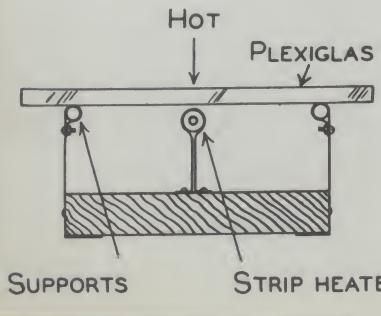


Figure 31

FORMING OF PLEXIGLAS

Forming sheet Plexiglas involves heating the sheet until it becomes soft and pliable and then shaping it to the form desired, using hand or mechanical means as the particular case requires. The heating may be done in many ways, but the home craftsman will probably find a strip heater, such as is described below, together with a simple oven, will meet his needs.

STRIP HEATERS

Essentially a strip heater is simply a device to heat the Plexiglas in a line only. A nichrome wire resistance coil of the type used in many electric irons or heaters is recommended as the heating element. A strip heater three feet long can be made from an ordinary twelve inch nichrome wire replacement unit. On 110 volts such a wire will heat to about red heat. Additional resistance (such as a 200 watt lamp in series with the wire), will reduce the heat somewhat if the red hot wire is not desired.

The hot nichrome wire can be insulated with china clay or porcelain beads and can be held in a number of ways. Figure 30 shows the insulated wire held in a fold of sheet metal which is attached to a vertical board. In Figure 30a, the sheet metal is mounted on a horizontal board and metal rods or wires slightly higher than the heating coil support the Plexiglas, preventing direct contact with the hot coil. Still another method is shown in Figure 30b. In this case, the bare wire is set in grooves made of insulating board such as Transite. The drawing indicates a method of providing for air circulation in this type of construction.

These are only suggested methods of making strip heaters. There are, of course, many other methods and the ingenious craftsman will have no difficulty devising a heater that suits his particular shop. In production shops where steam is available, very satisfactory strip heating may be accomplished by placing the Plexiglas in contact with a clean bare steam pipe.

In using strip heaters, the Plexiglas is placed on, or near, the heating element and allowed to remain until it softens or "wilts." At this point, it can be bent in any way as desired. Direct contact between the Plexiglas and the heater is not recommended unless the heating element is cool enough not to burn the Plexiglas. There will probably be marks (commonly called mark-off) on the Plexiglas, imprinted by the heater, but they will usually disappear as the Plexiglas cools.

Thick Plexiglas may need to be heated on both sides to bring it to the right temperature. If much thick material is to be formed a double strip heater may be arranged so that both sides of the Plexiglas are heated at the same time.

When properly heated, thick, as well as thin, Plexiglas can be bent quite well giving corners that are smooth and clean. (*Figure 31.*) If the material is bent

before it is well heated, irregular corners result and the Plexiglas is likely to craze.

Since heating expands Plexiglas, there may be warping along the bend. That is, the Plexiglas tends to bow out, giving a convex rather than a straight line along the bend. This is particularly true if the bend occurs close to an edge of the material. It can be largely avoided by holding the material in a clamp or jig until it cools. With small objects, the warping is of little importance and may usually be disregarded.

In parts formed by strip heating, internal stresses are set up. In small objects the stresses are usually unimportant, but in larger pieces they tend to weaken the article and should be removed by annealing. This is easily done by heating the article to 120°—150° F. for a few hours and cooling slowly. In the absence of an annealing oven, the part may be heated over a radiator or on a black surface in the sun.

Figure 32 illustrates the use of strip heating, to form a double bend corner. The piece is first made into a U shape by two successive heatings and bends as illustrated. The center of the U is then heated and the two outside corners are bent around until they touch. Such a corner is very useful for box legs and other decorative effects.

Figure 33 shows how a piece of Plexiglas may be folded over on itself and held with a padded clamp until cool. In Figure 34, a simple forming jig for making right angle bends is illustrated.

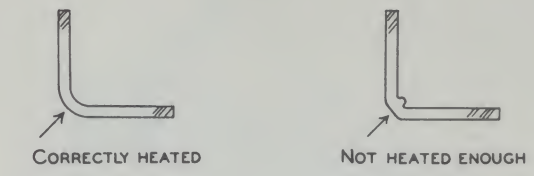
The home craftsman will probably heat and form one bend at a time. For production work, however, strip heaters and jigs should be so arranged as to make all the folds in one operation. These arrangements will, of course, be designed to suit the needs of the individual fabricator.

The commercial fabricator and the home craftsman alike will find various types of adjustable jigs useful. Figure 35 shows a simple and practical jig adjustable to a wide range of angles.

Figure 36 shows how the strip heater helps make lipped edges or ridges in a piece. The lip is formed by heating the edge of the Plexiglas over the strip heater, and then pressing it on a flat surface. The ridge is made by simply pressing the piece as indicated until the heated portion buckles up.

CONSTRUCTION AND USES OF HEATING OVENS

Many home craftsmen will use the oven of the kitchen stove to heat Plexiglas for the forming operations not done over the strip heaters. Such ovens are usually thermostatically controlled and can easily be kept in the temperature range between 220° and 300°F. recommended for forming Plexiglas. Cloth covered trays



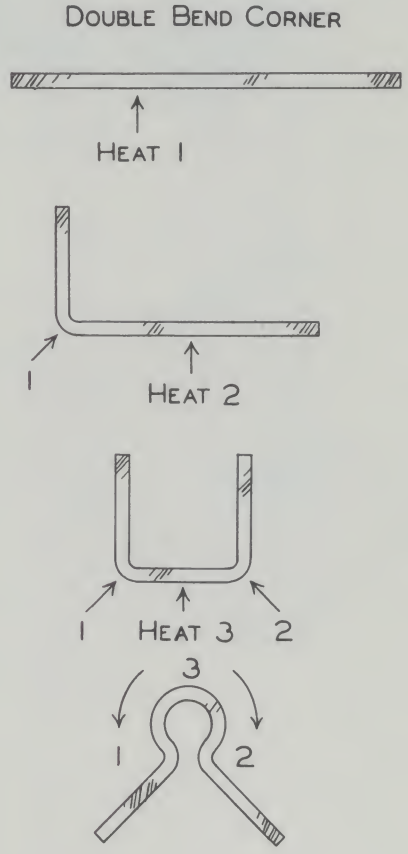


Figure 32

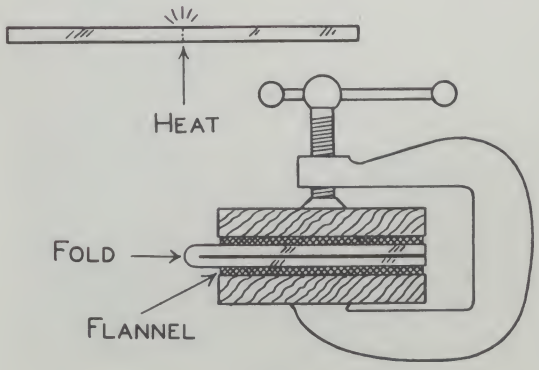


Figure 33

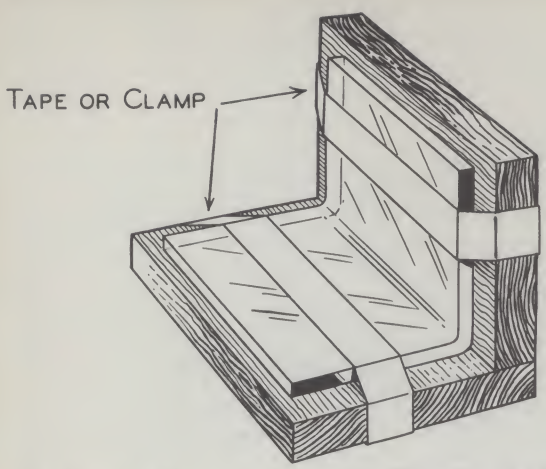


Figure 34 RIGHT ANGLE JIG

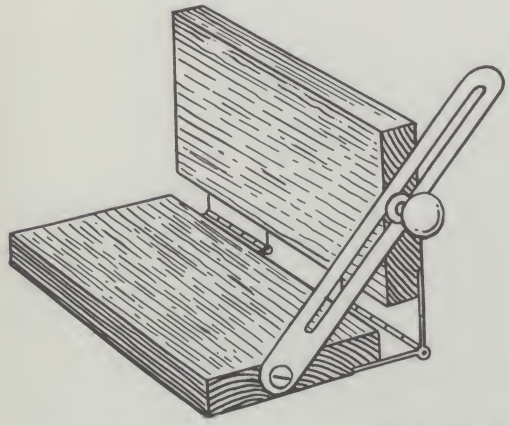
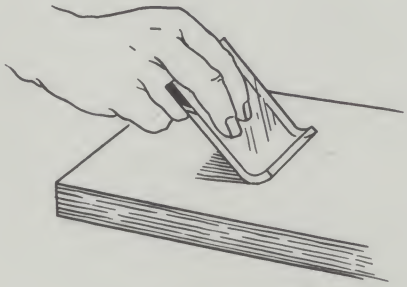


Figure 35



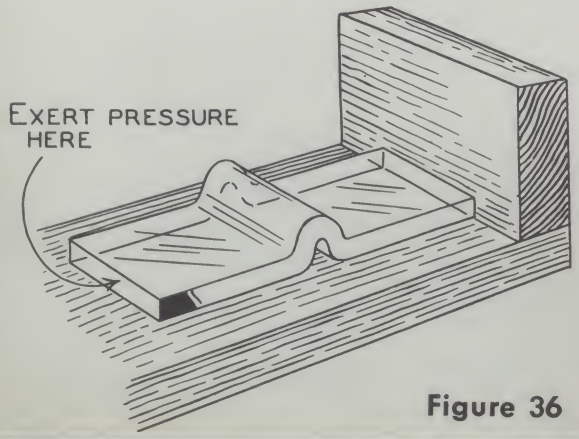


Figure 36

should be substituted for the usual wire racks if the kitchen stove oven is used. Ovens specially designed for heating Plexiglas need not be complicated or expensive, however, and many craftsmen prefer to build their own. Suggested types are described here to assist the craftsman or fabricator.

Small ovens are usually provided with cloth covered sliding trays, and the Plexiglas is heated as it lies flat in the tray. (*Figures 37 and 37a.*) Larger ovens may have provision for removing the shelves and hanging the Plexiglas sheet vertically from the top of the oven. Tubular spring clips (of the type commonly known as bulldog clips) are attached to the edge of the sheet, spaced only a few inches apart. The sheet is then slid into a suitably designed rack fastened to the top of the oven, thus suspending the Plexiglas vertically in the oven. (*See Figure 38.*) This method is especially useful for reheating formed pieces that are too bulky for heating in a drawer.

The small fabrication shop will seldom have need to handle sheets larger than 36 x 48 inches. Many find still smaller ovens satisfactory. For occasional handling of larger sized sheets, the sheet can be folded over a strip heater before being placed in the oven. In this case, cotton flannel should be inserted in the fold to prevent the surfaces of Plexiglas from touching.

Any of several methods may be used to heat the ovens—steam, gas, electric coil and infra-red all have their place. For ovens in the small shop, the electric coil is probably the most convenient source of heat.

Regardless of the method used to heat the Plexiglas, care must be taken to avoid heating the material too long or at too high a temperature, since excessive heating tends to produce a slight yellow color.

FORMING TECHNIQUES

Only a few of the more fundamental methods of forming heated Plexiglas are described here. There are, of course, many possible variations of the methods and the fabricator will work out processes suitable to his particular problems.

Soft cotton flannel gloves should be worn when working with hot Plexiglas. With most gloves, a softer surface is obtained if the gloves are turned inside out. Double thickness gloves are helpful for holding hot Plexiglas while it cools.

Many forming processes are done entirely by hand, (*Figure 39*) or with the aid of only a vise or clamp. In others, simple jigs may be provided, but an elaborate set-up of jigs and equipment is rarely needed in the home shop. The production fabricator will, of course, need more equipment in order to secure the necessary efficiency of operation.

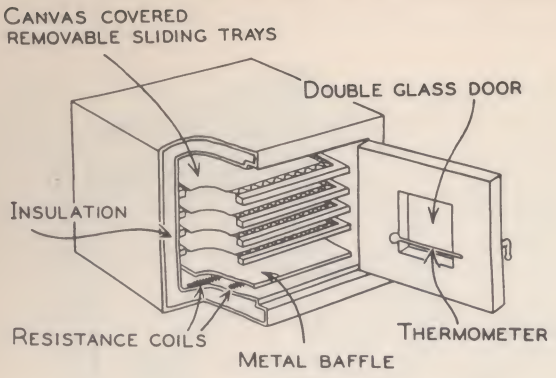


Figure 37

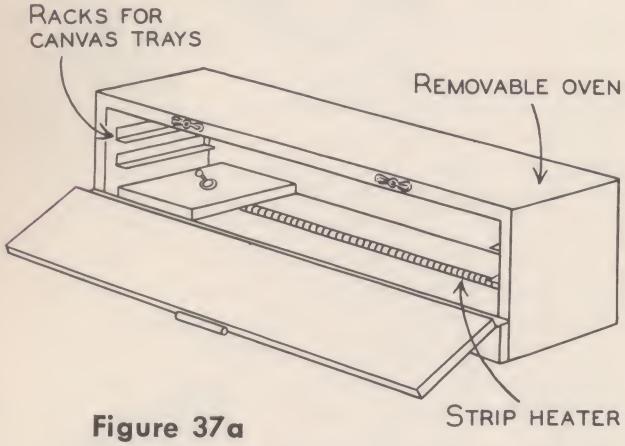


Figure 37a

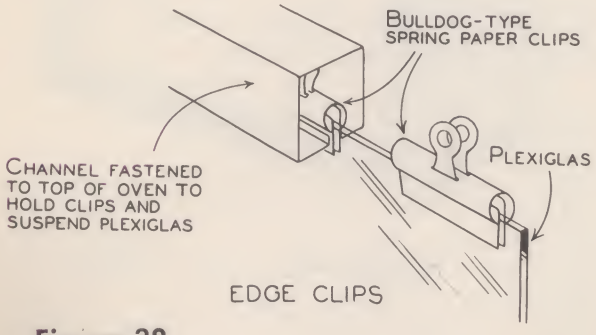


Figure 38

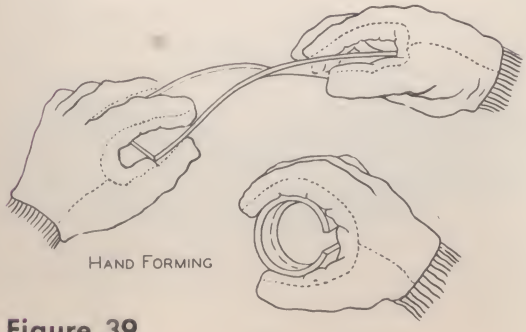


Figure 39

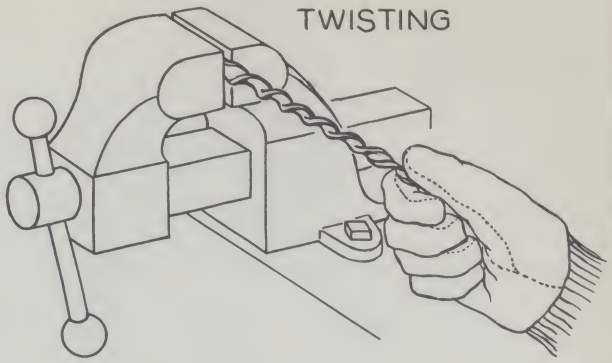


Figure 40

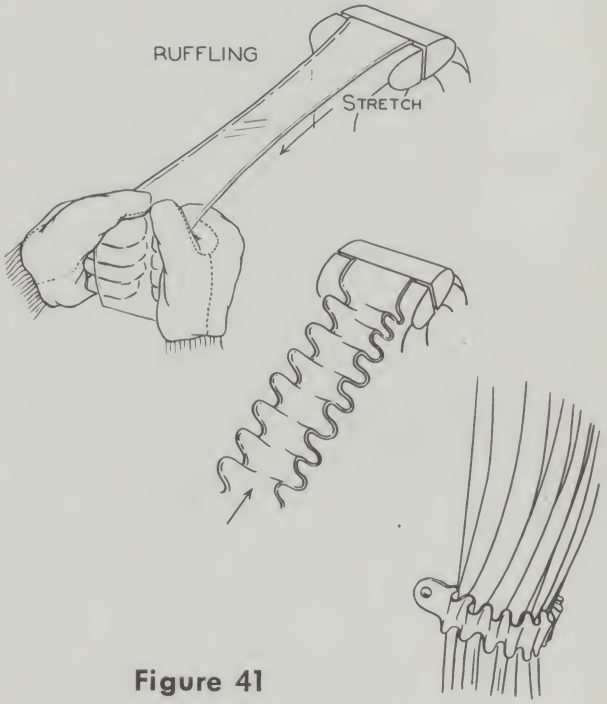


Figure 41

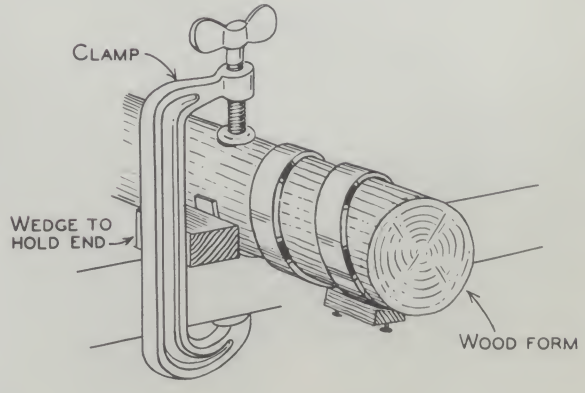


Figure 42

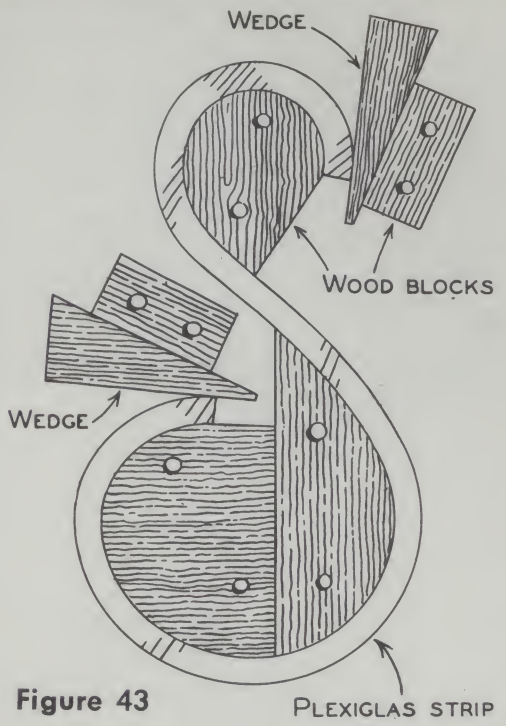


Figure 43

A HALF ROUND

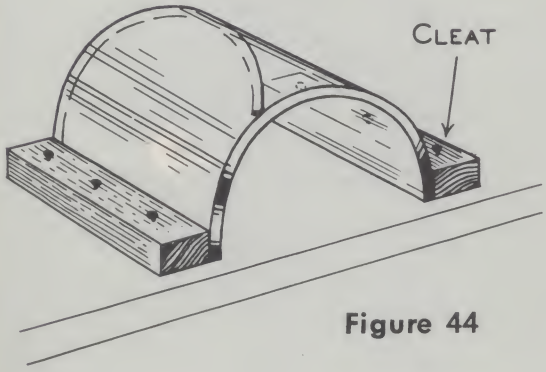


Figure 44

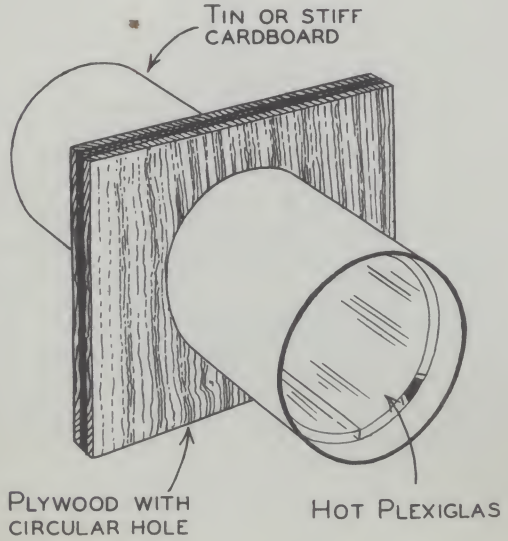


Figure 45

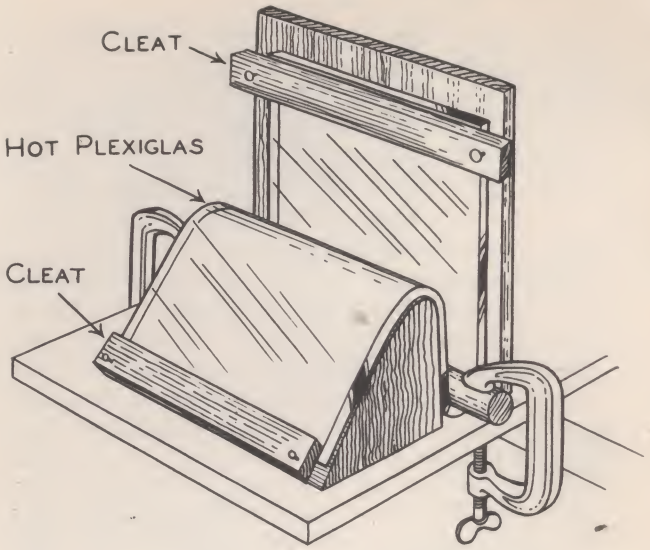


Figure 46

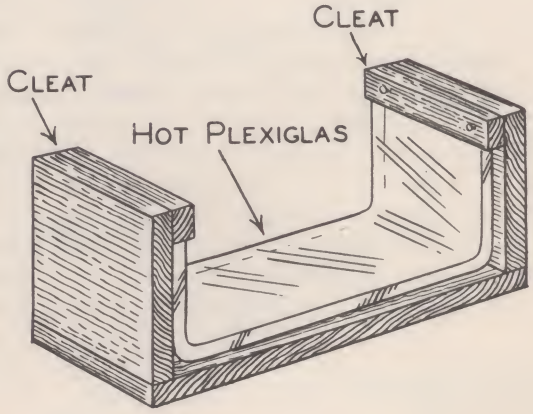


Figure 46a

DRAPING

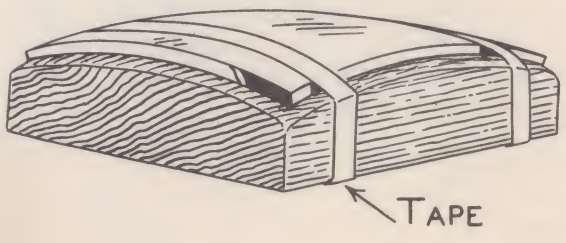


Figure 47

Twisting a strip of Plexiglas by clamping one end of the material and twisting the other by hand is a simple means of producing pleasing articles. (*See Figure 40.*) To keep the twist regular, the strip should be rubbed as it is twisted, or twisted part at a time. After twisting, the piece may be held straight or quickly turned to form a circle, spiral or other shape as desired.

Ruffling is produced by stretching a strip of Plexiglas as shown in Figure 41. The edges of the material cool before the center and if a half-cooled, stretched piece is released, the attempt of the Plexiglas to return to its former length will cause a ruffling effect along the edges. Curved into loops, ruffled pieces of this sort make decorative tie-backs for curtains.

Simple jig and clamp arrangements permit forming of a variety of shapes. A spiral, such as might be formed for a bracelet, is easily made with the clamp device shown in Figure 42. Figure 43 shows a practical means of holding an S shape while it cools. A half-cylinder is made by the simple device shown in figure 44, tension being supplied by the hot Plexiglas itself as it attempts, in cooling, to return to a flat sheet.

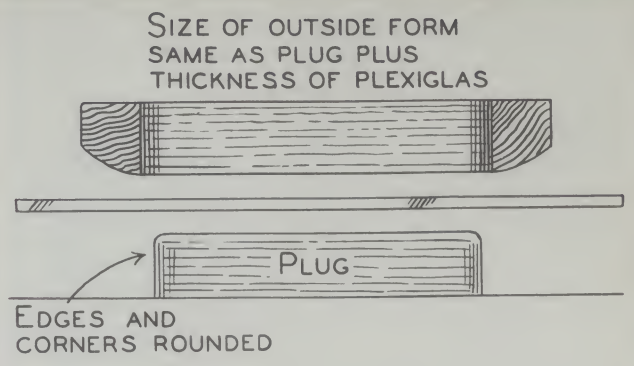
A cylinder of Plexiglas may be made in a tin or cardboard tube as shown in Figure 45. The "mark-off" on the Plexiglas resulting from contact with the tube can be polished off after the material has cooled.

Figures 46 and 46a, showing jigs which might be used for forming other shapes, are included to suggest additional ways in which a fabricator may arrange jigs for forming Plexiglas. Although, as has been said, a great many articles may be made of Plexiglas, without complicated fixtures, it is important, when jigs are needed, that the proper design be used. The commercial fabricator will find the designing of jigs an important part of his work.

Draping Plexiglas over a form, either convex or concave, is a useful means for shaping shallow three-dimensional curves. The method is illustrated in Figure 47. A wood or plaster form covered with stretched cotton flannel or flocked rubber, is generally used. The hot Plexiglas is placed on the form and rubbed gently with cotton gloves or a ball of flannel to bring the material to the contour of the form. With some types of molds, rubber bands can be used to hold the edges of the Plexiglas to the form until the plastic cools. In other cases, it will be easier for the craftsman to hold the Plexiglas in place by simply continuing to press it against the form with the flannel or gloves until it cools and hardens.

PLUG AND RING FORMING

A type of forming fixture, which, with its many possible variations, is a very useful aid to the fabricator is known as the plug and ring. Figures 49 and 50 illustrate various modifications of the jig. As will be seen in Figure 48, the so-called "ring" is not neces-



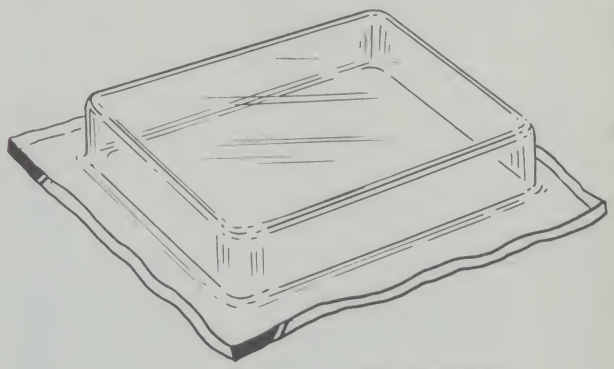
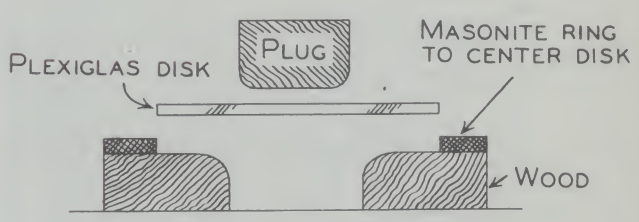


Figure 48



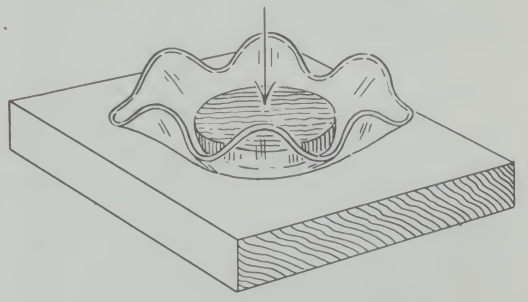


Figure 49

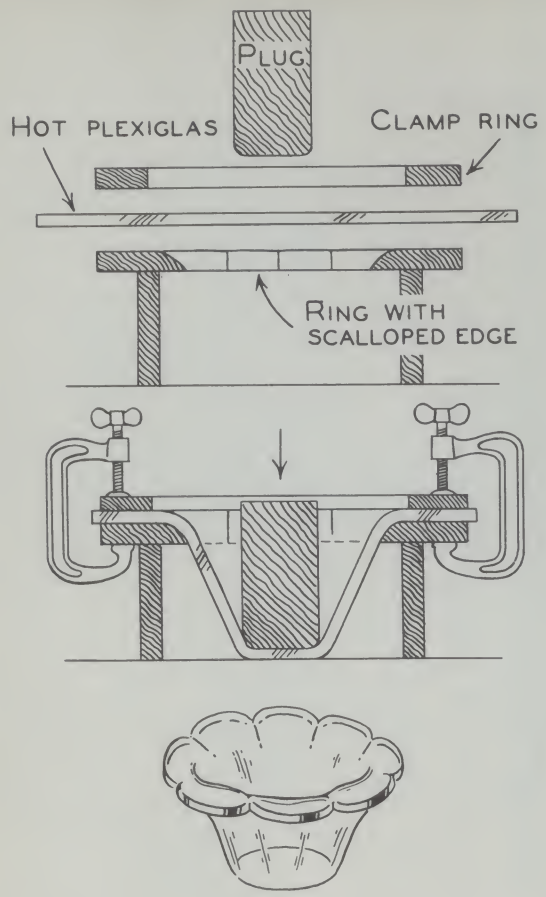
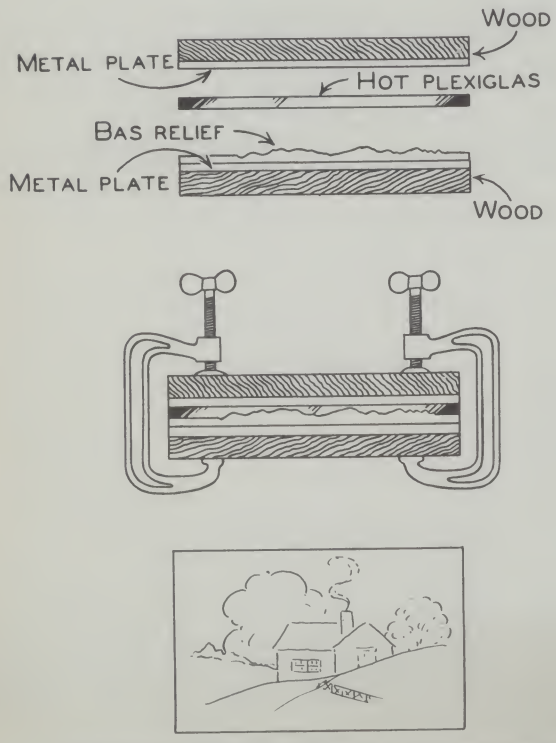


Figure 50



DESIGN SURFACE MOLDED INTO PLEXIGLAS

Figure 51

sarily a circular shape. Rather it is a band, shaped to the contour of the plug which is the mold for the part to be formed. In use, the hot Plexiglas is placed over the "plug" (usually a wooden form) and the ring is brought down over it as shown in the drawing. The Plexiglas can be drawn in this way to a surprising depth before it starts to wrinkle. The fact that it will eventually wrinkle is also interesting to the fabricator for dishes with wavy edges are produced by the method. A disc of hot Plexiglas, its edges polished, is set over the ring in a depression that aligns it. The plug, brought down in the ring, makes the dish itself, while the edges ruffle into a series of graceful waves, which, with a little hand forming, can be made quite symmetrical.

The plug and ring is a very useful forming fixture, especially suited to the making of boxes, lids, trays, dishes and similar shallow parts. In its usual form, however, it has the disadvantage of producing excessive mark-off, and since the pressure is especially great at the inside corners, the mark-off also is most pronounced at these points, and removal is difficult. A modification of the method which reduces the amount of mark-off is illustrated in Figure 50. The hot Plexiglas is clamped over a form and the center of the suspended material is pushed in with a plug. There is less mark-off with this procedure and since the clamping ring can have practically any desired design, great variation of shape is possible.

SURFACE MOLDING

Mark-off, usually objectionable, becomes an attractive method of decoration in the surface molding process illustrated in Figure 51. The process consists of pressing the sheet of hot Plexiglas against the pattern to be transferred, maintaining the pressure until the Plexiglas cools. The texture of cloth, wood or embossed paper is easily reproduced by this method as well as carved, shallow relief or other designs.

In embossing flat sheets of Plexiglas, flat plates of polished metal or pieces of heat-resistant plate glass serve as the "platens" to press the Plexiglas and the pattern together. If necessary, heavy wood backing plates may be used to reinforce the platens. Pressure may be applied by any convenient method. A vise is good; a letter-press is better, but satisfactory results can be obtained with the pressure of dead weight alone.

A surface pattern can also be applied during the forming operation by applying the pattern to the mold surface.

BLOW AND VACUUM FORMING

In addition to the hand and mechanical methods of forming which have been described, the commercial fabricator will find use for the more complicated blow

or vacuum processes. Because these methods require equipment not usually available in the home shop, only brief discussion of the more simple processes is included here.

Blow forming, as the name implies, consists of blowing hot Plexiglas into desired shapes by means of air pressure. Vacuum forming is essentially the same except the "blowing" is done by the pressure of the atmosphere against one side of hot Plexiglas after a vacuum is established on the other side.

Blow forming produces essentially spherical shapes, but the final form may be so greatly modified by various controllable factors that actually a very wide variety of forms may be produced.

Figure 52 illustrates a simple method of blow forming. The home craftsman, desiring to experiment with the process, will find it possible to do simple pressure blowing with only a tire pump as the air supply. The hot Plexiglas must be clamped firmly to the rubber gasket with a plywood or metal ring. As air is forced under the plastic, the material blows out into a bubble. When the desired size is reached, the air pressure is held constant until the Plexiglas cools. The ring need not be circular—it may be square, rectangular, oval or irregular. The resulting Plexiglas shape has the outline of the ring at the edge and tends toward a spherical shape in the center.

Figure 53 shows a typical set-up for blowing hot Plexiglas into a mold. This process is rather involved and is not likely to be used by the home craftsman or the small fabricator.

Attractive bowls or covers are formed by blowing. After being formed, the waste is cut off and the edges finished, completing the bowl. An improved edge is obtained if the edge is reheated, permitting it to draw back enough to regain its original thickness. (*See Figure 54.*) To prevent collapse of the entire piece, the bowl should be nearly filled with water before being placed in the oven for this reheating.

As shown in Figure 55, a "slice" from the top of a spherical section blown from a piece of heavy Plexiglas, will produce a very good plano-convex (magnifying) lens. A similar piece cut from the bottom of the blown part produces a plano-concave (reducing) lens.

MARK-OFF

Occasional reference to "mark-off" has been made from time to time. It is a source of possible trouble whenever hot Plexiglas is being handled and therefore merits more detailed discussion.

In forming operations involving the use of molds, mark-off is reduced by coating the mold surface with a heavy oil or grease. Castor oil is good for this pur-

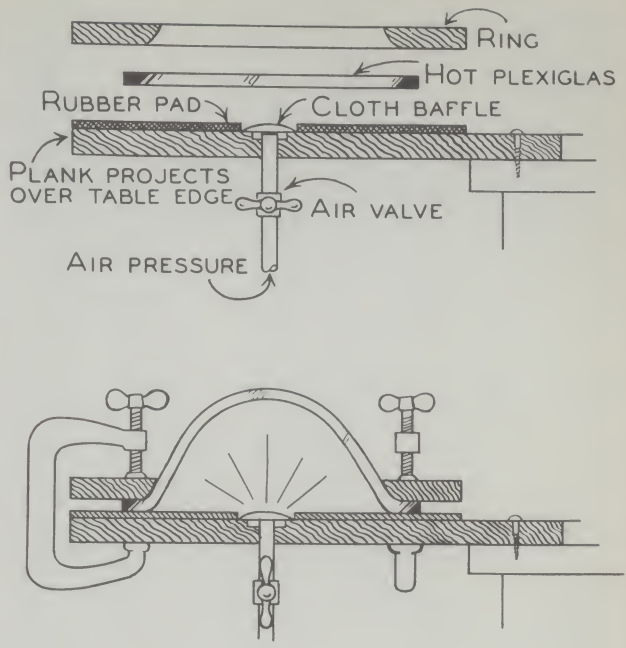


Figure 52

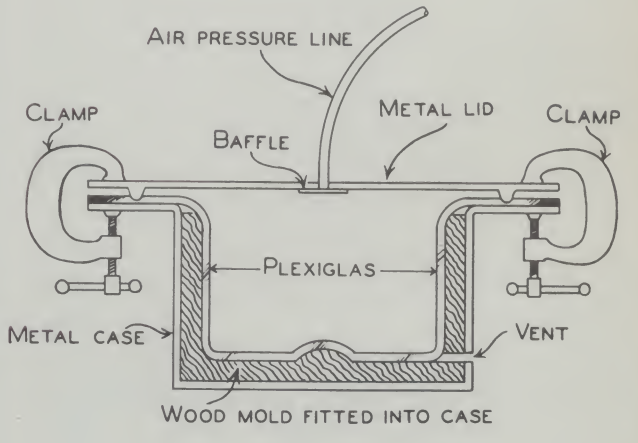


Figure 53

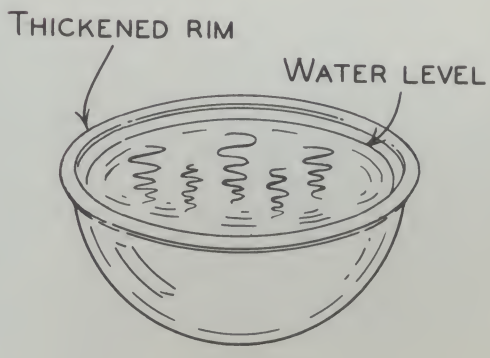


Figure 54

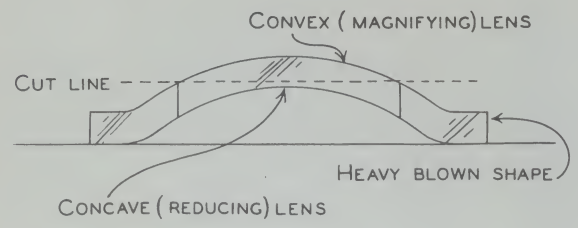


Figure 55

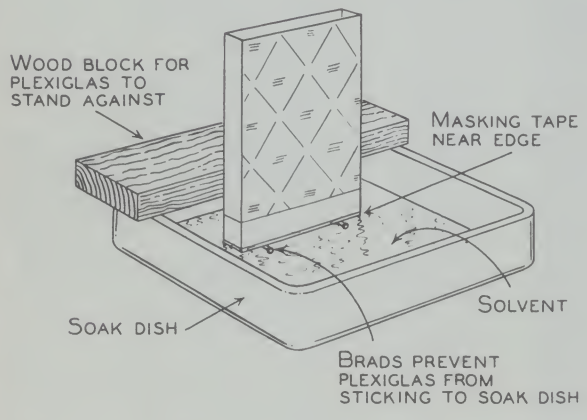


Figure 56

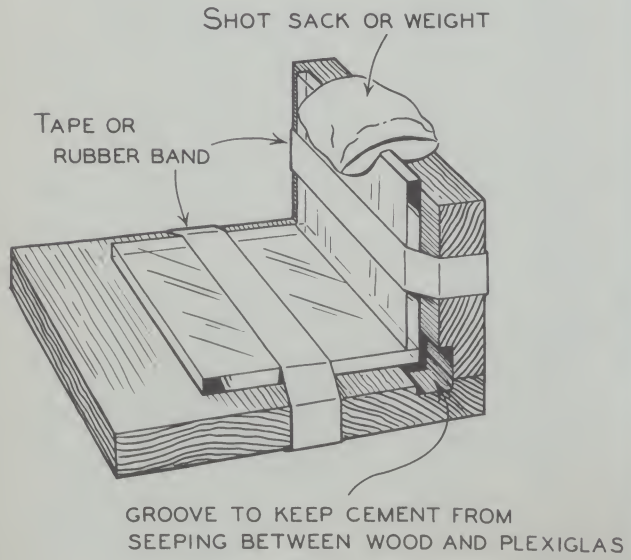


Figure 57

pose since it does not thin out excessively under the heat of the softened Plexiglas.

When it is possible to move the Plexiglas slightly on the mold as it cools, mark-off is reduced. Vibrating systems have been devised to produce this effect.

Mark-off can be removed by reheating the Plexiglas and this method is used widely in salvage operations. It can be used on finished articles as well, if one side of the piece can be kept cool to prevent collapse of the article. Many Plexiglas articles can be filled with water and placed in the oven. Mark-off on the outside surface is removed in this way without softening the entire piece. For interior mark-off it is sometimes possible to weight the article down in water, leaving the inside empty.

In a great many cases, however, mark-off must be removed by sanding, buffing and polishing methods. Short-cuts, such as "flaming," increase the crazing tendencies and are not recommended.

JOINING PLEXIGLAS

The usual types of adhesive cements or glues, such as are commonly used in woodworking, have little use in working with Plexiglas. They may be employed to join flat opaque or translucent sheets where the joint is not seen or to fasten cloth, wood, metal or other material to the Plexiglas. When glues and cements of this type are used, the Plexiglas should be sanded to provide a surface with a little "tooth" to increase the strength of the bond, and flexible adhesives such as are commonly sold as "household cements" should be used.

For regular fabricating operations, however, where Plexiglas is to be cemented to Plexiglas, adhesive glues and cements are not recommended. A *cohesive* cement is needed; that is, one that softens the surfaces of the plastic so that the two parts actually become a single unit. These cements are essentially Plexiglas solvents, and when they are properly used, they produce transparent, strong, cemented joints. To secure really good results, much care and considerable skill are required; yet the technique is easily learned and the home craftsman derives much satisfaction from his ability to produce perfect cemented joints.

More preparation is required for good cementing with Plexiglas than for gluing wood joints. The fit must be very close, jigs or clamps must be properly adjusted, masking is often required, and the cement must be carefully applied.

The proper fit of the Plexiglas parts is easily tested by wetting one surface and closing the joint. If the fit is good, an even film of water will be spread throughout the joint. When two curves are to be cemented, a good fit can be secured by heating one side and pressing it against the other which is unheated. Flat straight sur-

faces are always easiest to cement. A surface can be made quite flat by wet-sanding it on a sheet of "wet-or-dry" sandpaper laid on a flat surface.

Just before the cement is applied, the area around the joint should be masked with a pressure adhesive tape that will not be affected by the cement. The tape should be carefully rubbed down to prevent seepage of cement under it, and removed when the joint has set up, before it is quite hard. With proper care and a steady hand, masking may be omitted in many types of joints, but is a worthwhile precaution.

As has been said, the cements to be used are solvent in action. Ethylene dichloride (EDC) and Cement 1-C (known chemically as 1, 1, 2 trichloro-ethane) are widely used. Other materials which can be used are methylene dichloride (MDC), chloroform, glacial acetic acid and acetone, listed in the order of their desirability. These cements vary as to speed of action and other handling characteristics.

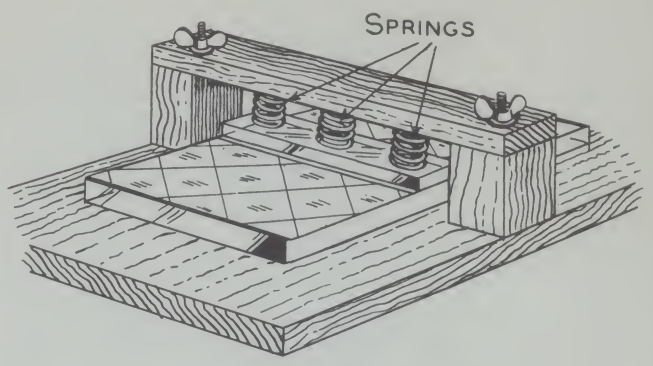
The recommended cements are very thin and fluid. There may be certain joints for which a more viscous cement is preferable. If so, Plexiglas chips can be added to the solvent. These cements are slower acting than the straight solvents but they eventually form strong joints.

The cement may be applied in several ways. The most usual method is to soak one of the edges to be joined until it is swollen into a "cushion" by the solvent action of the cement. (*Figure 56.*) The time required to produce the necessary cushion will vary according to the cement used and the joint to be made but 30 seconds to 3 minutes are the usual periods. Soaking time should be long enough to form an adequate cushion, but if too deep a cushion is formed too much material will be extruded at the joint and a long hardening period must be allowed. When sufficient cushion has been obtained, the two edges are brought together without delay, while the cushion is still wet with solvent. The solvent causes the opposite dry surface to swell into the cushion, forming the joint. The cushion serves to hold the cement needed in the joint and helps to close a joint that is not perfectly fitted.

As soon as the edges are joined, the assembly is placed in the clamp or jig and left to harden. Just enough jig pressure to squeeze out the air bubbles is recommended. Greater pressure will squeeze out the cement and cause dry spots. Small pieces can often be weighted with bags of shot, tied with cord, or taped, to supply the required pressure. (*Figure 57.*)

Many cementing difficulties come from defective clamping methods. The necessary jigs and fixtures should be provided before the cement is applied and tested to make sure they will operate as needed. Figures 58, 59 and 60 are suggested clamping devices.

After the cemented assembly is placed in the jig, it should be carefully inspected. If dry spots are pres-



CEMENTING A RIB ON A SHEET

Figure 58

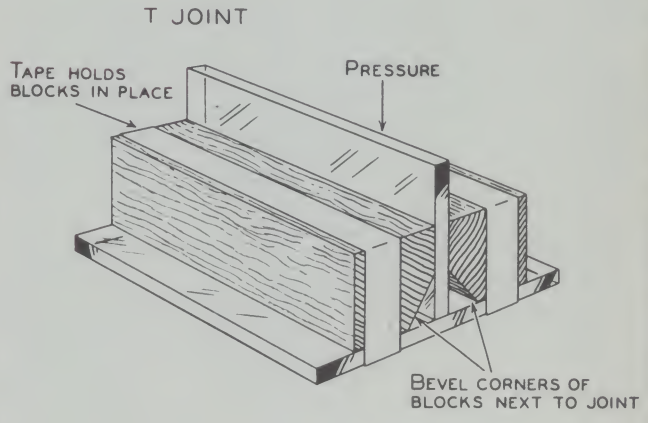


Figure 59

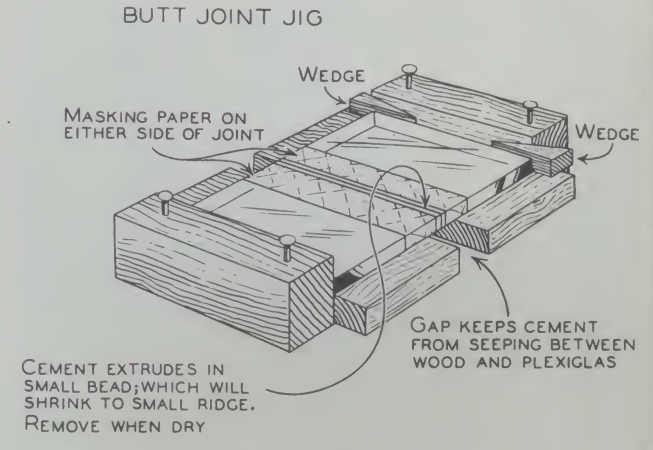


Figure 60

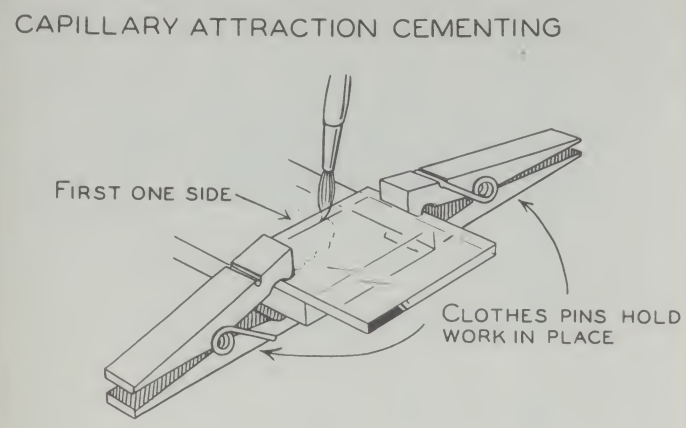


Figure 61a

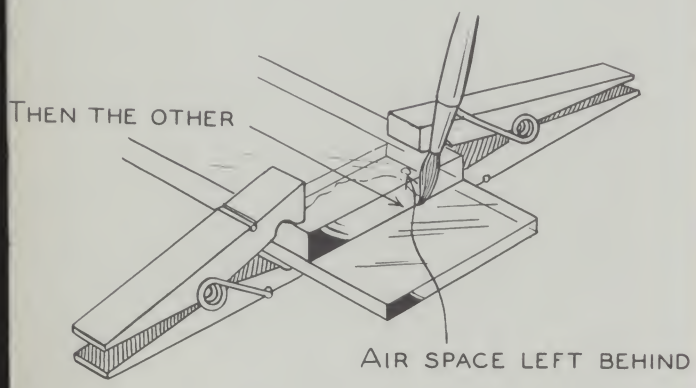


Figure 61b

Figure 61c

ent the joint should be opened, soaked again in the solvent, and reclamped, unless the spots are small and can be reached by a hypodermic needle. In this case, additional solvent can be introduced at the exact spot required with the needle and the rest of the joint need not be disturbed.

Instead of soaking the Plexiglas in the cement, it is sometimes possible to merely dip the piece in the cement, or to pour the cement on the edges, and join. When the parts fit perfectly, this method will produce a good joint. When cementing a flat strip onto a surface, the solvent may be applied by running it down along the strip with a brush, eyedropper or hypodermic needle (*See Figures 61a, 61b and 61c*), depending on capillary attraction to draw it underneath the strip where it is needed. Trapped air is then removed by slight pressure and the joint is left to set up under similar pressure.

Cemented joints should be left at least 24 hours before "cleaning up." The time can be reduced by heating for a few hours at 150°F. and the resulting joint will be stronger. Heat should not be applied, however, until the joint has set up—usually fifteen to twenty minutes.

The solvent cements discussed here are toxic and most of them are inflammable. Inhaling the concentrated vapors for extended periods may cause illness, so the worker should provide adequate ventilation, away from fire, for the operation.

The preceding discussion shows how Plexiglas may be cemented to form strong, perfect joints. At the same time the difficulties have been pointed out. In general, the craftsman will want to avoid cementing whenever possible, for the operation will be found time-consuming and very exacting.

WELDING

Plexiglas can be welded. In the process both surfaces to be joined are heated on a hot plate until they are bubbling and smoking slightly (about 660°F.). They are then brought together quickly and held until cool under sufficient pressure to exclude air. The resulting joint, if it has been kept clean, may be sanded and polished into a strong transparent seam.

Welding is most practical for the production shop where it may be used to join large sheets of Plexiglas. The requirements of carefully controlled temperature, absolute freedom from dust or dirt, and fast application of just the right pressure makes the process too exacting for the average home shop. The home craftsman often enjoys experimenting with welding, however, and may find amusement in joining various colors together to make novelty pieces.

DESIGN

The craftsman will find the proper design of a Plexiglas part is often of greater importance than its decoration. An object of poor design cannot be corrected by any amount of decoration; on the other hand an article that is pleasing in proportions and designed to fulfill its functions often needs no decoration.

Good design involves more than these considerations of proportion and function. It includes, also, choice of proper materials and the correct use of the materials chosen. The designer must know the characteristics of the material he works with—its limitations as well as its advantages.

The worker in Plexiglas will be especially interested in the following characteristics of the material:

(1) Heat sensitiveness

The fact that Plexiglas softens when heated and, in this condition, can be shaped as desired has been discussed previously as one of the valuable properties of the material. Obviously, however, this characteristic makes the acrylic plastics unsuitable for use near fire or excessive heat. The acrylics will burn slowly (about like wood), when placed in an open flame, although red hot metals will not ignite them (*See Figure 62.*)

Plexiglas is not recommended for radiator covers or for articles used around stoves, (handles on pans or Pyrex dishes, for example). (*See Figure 63.*) It is satisfactory for bathroom fixtures, since the hot water normally found there is not hot enough to harm Plexiglas.

Plexiglas is not recommended as the sole material for ash trays, but practical as well as attractive Plexiglas trays are produced by including a metallic liner in the design to shield the Plexiglas from direct contact with heat.

In lighting Plexiglas, avoid direct contact between Plexiglas and incandescent bulbs. Fluorescent tubes, however, are not hot enough to harm the material. (*See Figure 64.*)

(2) Cold flow

All plastics—in fact all materials—exhibit, in varying degree, a tendency to deform gradually under stress. Plexiglas stands high among the plastics in its resistance to this "cold flow", but the characteristic should be considered when large sheets of the plastic are used with relatively little support. In general, Plexiglas will sustain a stress of 1000 pounds per square inch without marked deformation from cold flow. A large flat ceiling panel supported only at the edges would probably sag, but if it were slightly "domed" to change the direction of the stresses, the tendency would be very greatly reduced. (*See Figure 65.*) Similarly, a flat shelf, supported only at the ends would sag. If the shelf is bent as shown in Figure 65, it will be rigid and retain its shape.

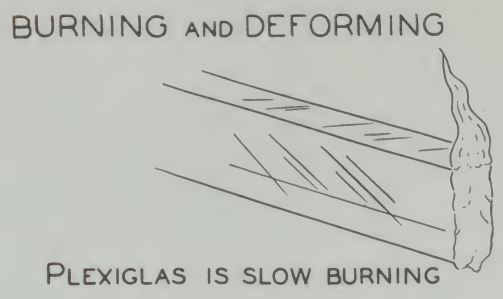


Figure 62

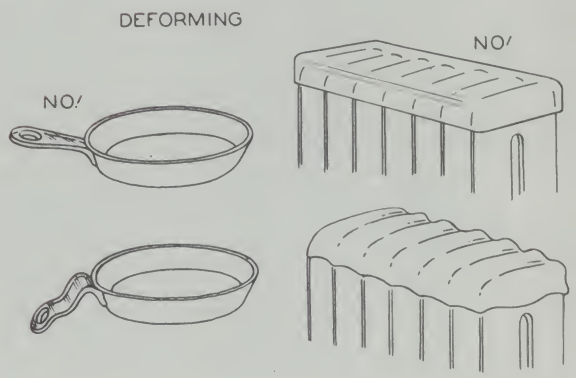
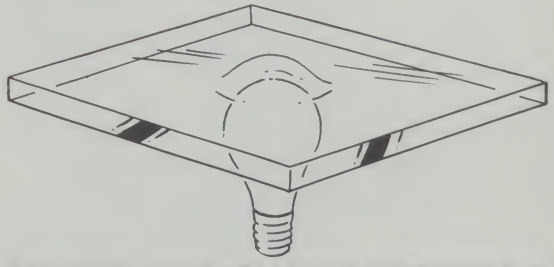


Figure 63



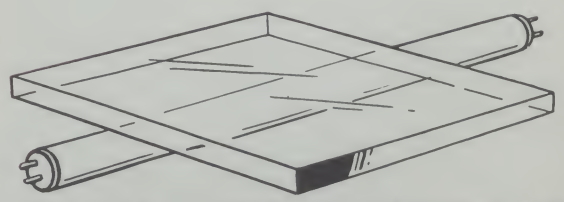


Figure 64

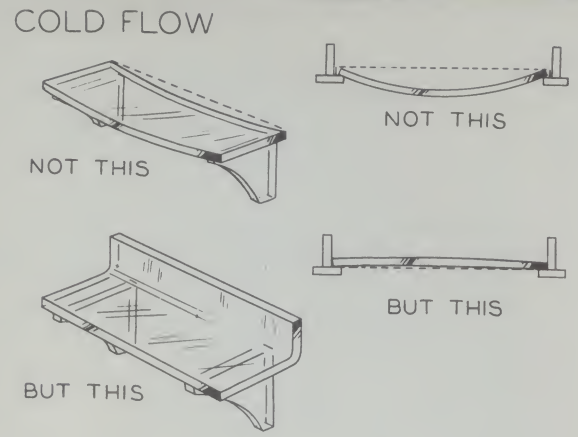


Figure 65

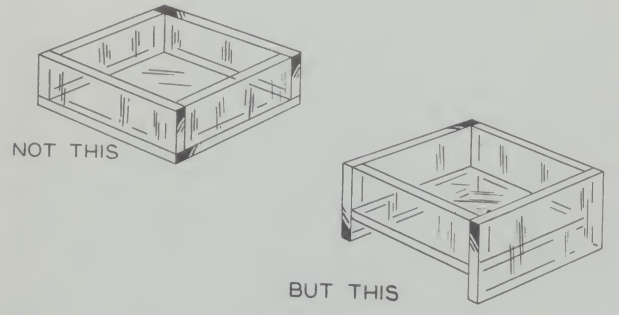


Figure 66

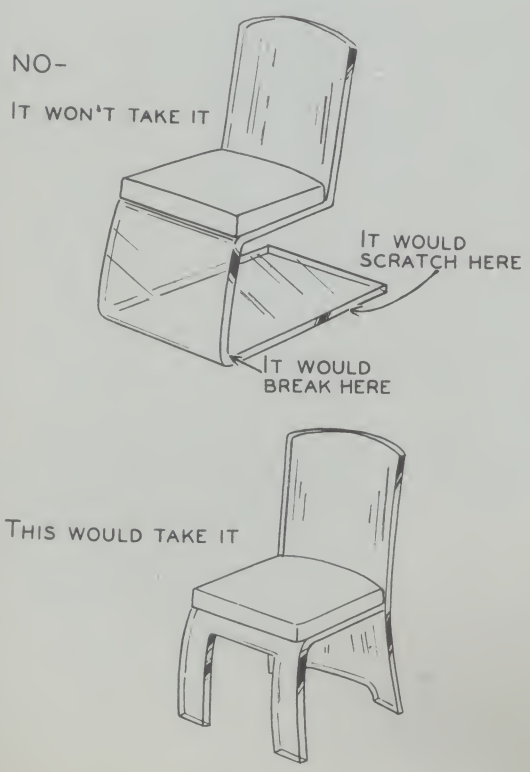


Figure 67

(3) Surface hardness

The surface of Plexiglas, although as brilliant as fine crystal, is much less hard. This makes it possible for the craftsman to bring his completed Plexiglas projects to a high polish readily and without undue effort. It also means, of course, that the material may be readily scratched and marred through misuse. Plexiglas should not be used for large flat areas where scratching is likely to occur. The bottom of a box or jewel case, for example, will scratch badly in normal use if legs or other support is not provided. (*Figure 66.*) It is good practice in places where the entire base serves as the support of the part to sand the area as part of the manufacture. A pleasing, silky surface that is unmarred by further abrasion is produced in this way. Wash basins have been made, using sanded Plexiglas; they retain their original satin-finish appearance unchanged under conditions that would seriously damage porcelain enamels.

In many articles, legs or other supports can be included in the design to avoid the surface marring difficulties otherwise experienced. Figure 67 illustrates this suggestion.

(4) Electrical properties

Plexiglas is an excellent insulator and is used in many applications in the electrical industry. As is typical of insulating materials, Plexiglas easily acquires a static charge. The buffing and polishing operations used in finishing Plexiglas articles often build up such charges causing dust and lint to collect on the material. Designers should take this into account and avoid designs having sharp inside corners or small openings that would be hard to clean. Moisture removes the static charge and cleaning is readily done by methods given on page 7.

(5) Reaction to solvents

As has been said, various organic solvents will react with Plexiglas, softening the surface. The cementing processes described on page 28 are made possible by this characteristic. Obviously, then, Plexiglas should not be used where it may come in contact with such materials. Compounds to be avoided include acetone, concentrated alcohol, cleaning fluids, chloroform, lysol, ether and other organic acids or solvents. With such materials, both the liquids and their vapors are harmful, softening the surface of the Plexiglas. The damage usually appears in the form of checking or crazing.

STRENGTH OF PLEXIGLAS

Plexiglas is extremely strong and properly designed parts are resilient and able to withstand great stress without breaking. In applications such as chair legs, a design similar to that commonly used with wood is recommended. (*See Figure 67.*) In any application, it should be remembered that although Plexiglas is extremely strong, it is not unbreakable and the designer should take the matter of strength into consideration.

PLEXIGLAS LEADS TO NEW DESIGN METHODS

The great transparency of Plexiglas, together with the fact that it is thermoplastic in nature gives the worker in Plexiglas a freedom in design that is not found in most other materials. Designers, accustomed to working with straight lines or regular geometric shapes, should not limit themselves to such patterns when designing with Plexiglas.

Although patterns and paper models are good and highly recommended for many projects, many excellent and original designs are evolved by simply working with the hot material itself—"cut and try." New shapes, too intricate for most craftsmen to handle from patterns, are produced this way and the design is normally entirely suited to the material, since it is formed rather automatically by the material itself.

DESIGN FOR BRILLIANCE

The extreme clarity of Plexiglas leads the designer to almost endless effects with light without requiring great technical knowledge of the laws of light behaviour. Fundamentally the designer should remember that light is reflected at an equal but opposite angle from a reflecting surface. Many of the most pleasing effects with Plexiglas are reflection phenomena.

Reflection from the inside surface of the back side of a Plexiglas part is especially attractive. This means that carving or facetting, to be fully effective, should be on the back of the sheet. Angles of 45°, producing practically total reflection, are especially effective. (*See Figures 68 and 69.*)

The lighting effects that may be produced with Plexiglas are so outstanding that the designer should give special attention to the matter of producing brilliance in Plexiglas parts.

Long, thin prisms, for example, can be bent into bracelets, made into hair ornaments, tied or twisted into amusing shapes for novelties, used in display fixtures or in many other applications. In any of these cases, the reflection from the prismatic surfaces back through the flat front surface, produces a reflection so brilliant, that the part seems to be silvered.

The effect is easily produced on flat pieces such as box lids, plaques, or signs by providing polished 45° grooves on the back side of the piece.

For full brilliance, all decorations should be on the reverse side of the Plexiglas. A half-round molding is most brilliant when seen from the flat side. Painting, seen through the transparency, appears especially luminous.

Brilliance not only makes an object more attractive; it makes it seem cleaner. Smudges or finger marks are unpleasantly apparent in plain transparent sheets. With pieces decorated for brilliance, occasional marks are scarcely noticeable.

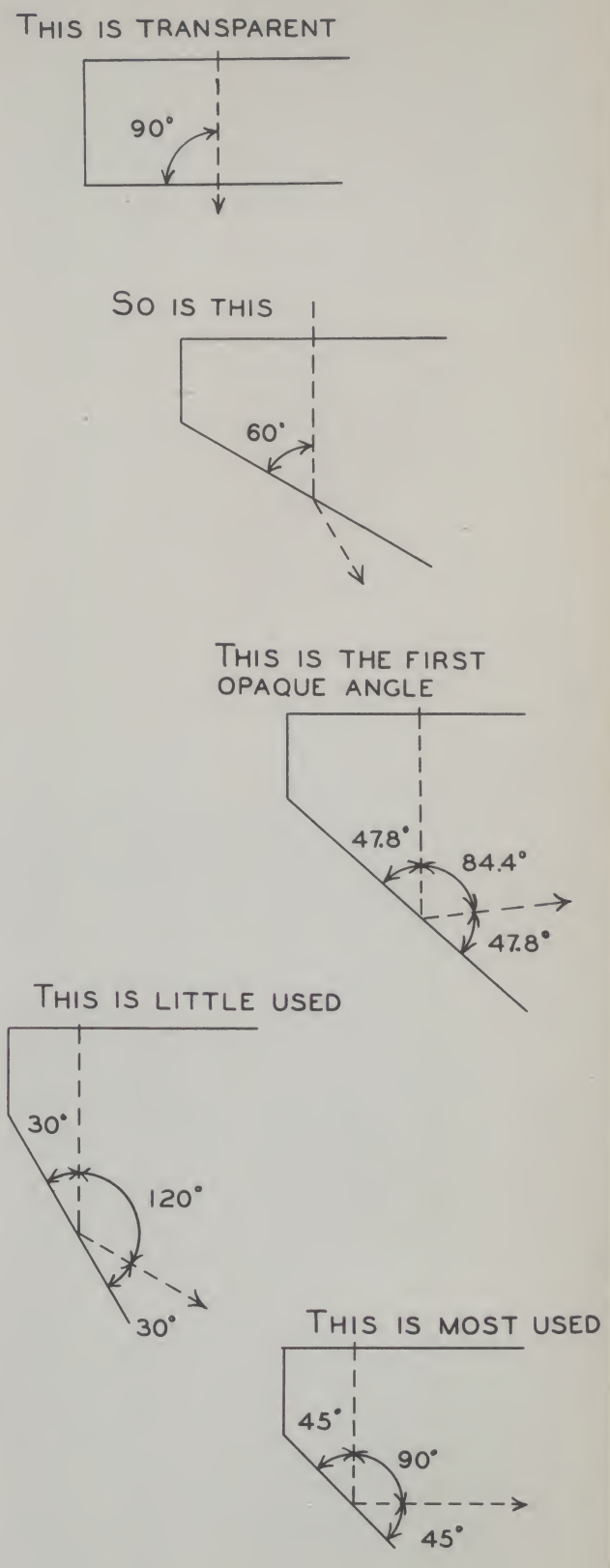


Figure 68

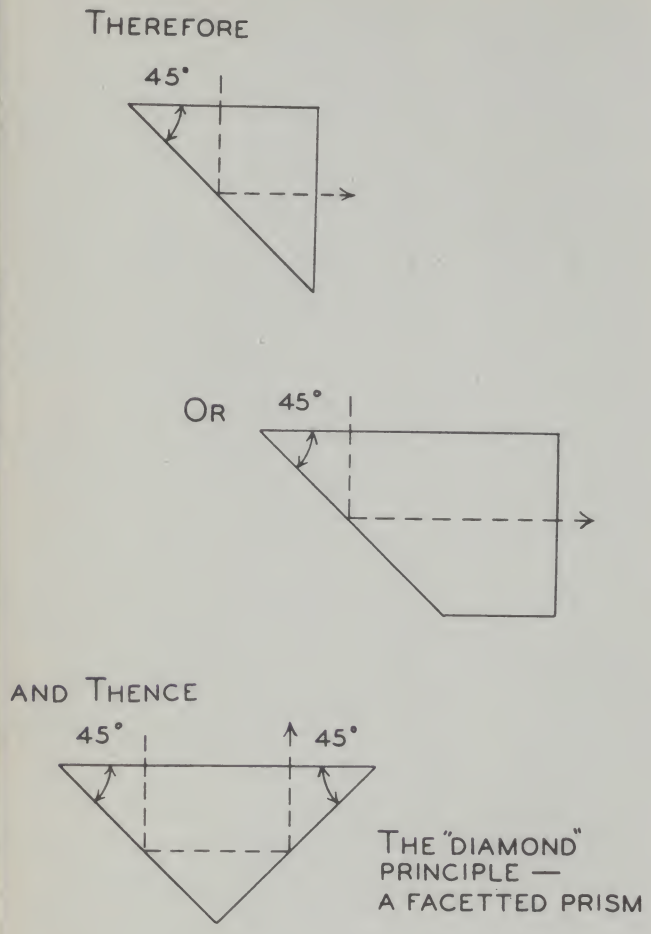


Figure 69

LIGHT PIPING AND EDGELIGHTING

One of the featured attractions of Plexiglas is found in light piping and edgelighting. Because of the almost perfect transparency of Plexiglas, light rebounds from its polished surfaces and remains in the Plexiglas, even following it around bends, (within limits indicated by Figure 70), leaving only at the opposite end or at sanded or machined spots along the way. This "light-piping" characteristic is, of course, present to a degree in any transparent material with polished surface; it is particularly spectacular in Plexiglas because Plexiglas is so very clear and can be so perfectly polished.

Designers can make much of light piping in objects which are not used with special light sources. For example, in the design of a jewel box, the top edges of the box may be polished and the bottom corners beveled or bent to an angle that will permit the light to travel around from one top edge to the other. The effect will be surprising. The edges will appear to glow, just from the room light they pick up. (*See Figure 71.*)

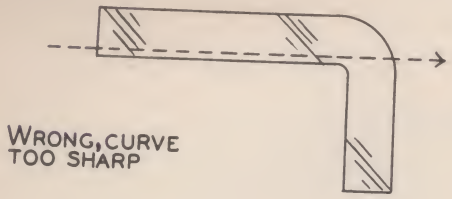
Edgelighting is fundamentally the same effect as lightpiping but is used in a different way. Light entering one side of a sheet, as was said, stays in the Plexiglas until it reaches the opposite edge, unless the polish of the surface along the way is broken. At any point where the polish is disturbed, light will escape. Therefore, if a design is placed on the sheet—painted, inscribed, engraved, sanded or carved—light will be emitted from the design and it will glow. With the source of the light hidden, the decoration will glow most mysteriously.

Applications are endless. Wall coverings, pictures, decorative panels, table tops, (under glass protective covering), signs and displays are typical edgelighting applications. The idea has already found wide application in the commercial field but it appears that the full possibilities of edgelighting are only touched. In art and decoration, edgelighted Plexiglas may well become a new medium for artistic expression.

There are several rules for edgelighting which must be considered in the design of an edgelighted panel:

1. Light source

A fluorescent or cold cathode type light is best for edgelighting Plexiglas, because it supplies a continuous line of light and because it is not hot enough to harm the sheet. The tube should be mounted as close to the edge of the sheet as possible without actually resting the sheet on the tube. An opaque enclosure for the tube is needed, fitted with a slot in which the Plexiglas panel fits snugly. This can be made of wood, metal or black (opaque or painted) Plexiglas. Figure 72 shows a satisfactory type of housing for a fluorescent tube used in edgelighting . Best results are obtained when the slot is slightly deeper than the thickness of the sheet and is lined with black felt or other light-absorbing material, so that light can enter



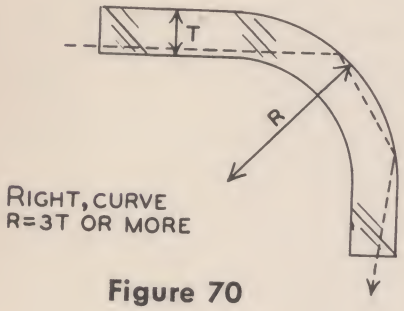


Figure 70

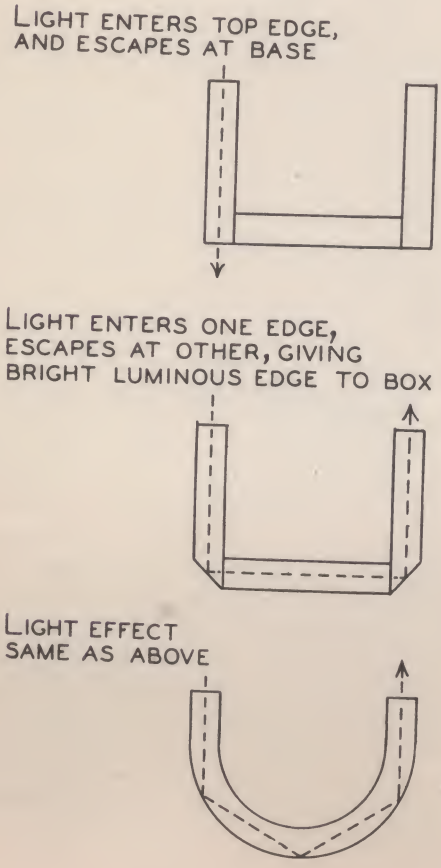
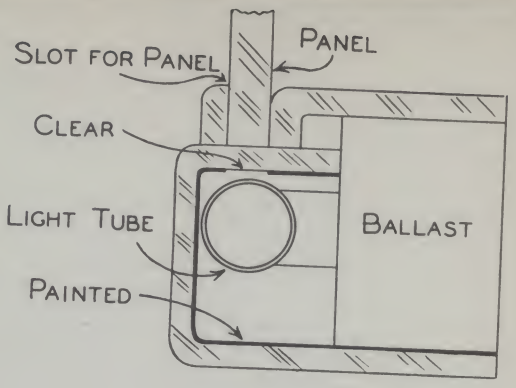


Figure 71



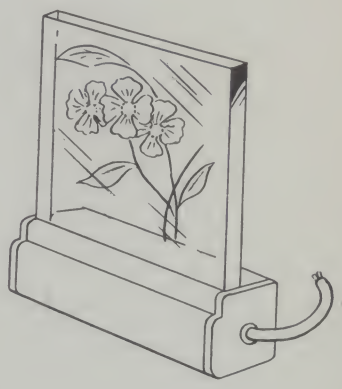
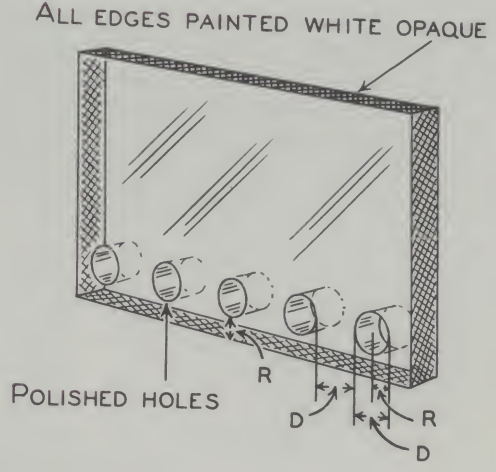


Figure 72



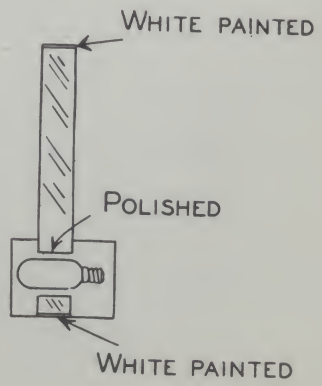


Figure 73

the sheet only through the edge and at a relatively small angle. Side edges should be polished and top edge painted white for best results.

In the absence of fluorescent lights, incandescent bulbs can be used but special arrangements are necessary, both because the light in this case is practically a point source, (instead of a line source), and because of the heat given off by such bulbs. Figure 73 illustrates a very effective means of using incandescent bulbs in edgelighting. A series of polished holes is made in the sheet near one (or more) of the edges and small bulbs are set in the holes. The distance of the holes from the edge of the sheet should be about the same as the radius of the holes and they should be about twice that distance apart along the edge. In this way, light enters the sheet from all points around the perimeters of the holes, and the effect of the row of bulbs is very much the same as that of a line-source light.

When this system of lighting is used, all four edges of the sheet should be painted opaque white to reflect back into the sheet the light that would otherwise escape from them. A small amount of light will diffuse from the white edges and appear as a glow around the surface of the sheet at the edge. If this is undesirable, the edge may be covered with a frame in some way for a distance slightly greater than the thickness of the sheet, thereby effectively hiding the escaping light.

2. Uniform Illumination

To obtain even illumination the area nearest the light source should have the least decoration while that farthest from the light should have the most. This is because the light, escaping as it strikes the design, would be largely dissipated by large areas of decoration near the source and relatively little light would be left for the more distant areas.

3. *Thickness of sheet*

The amount of light entering the sheet through the edge is naturally in proportion to the thickness of the sheet. Hence, more brilliant illumination results when thicker sheets are used. Sheets one-quarter of an inch thick are satisfactory for most applications.

In summarizing the discussion of edgelighting, the effects possible with natural edgelighting (*Page 34*) are again emphasized. Bevels on the bases of box shaped containers pipe light from one edge to the other. Engraving or decoration on the back of such a sheet will be even more luminous when this natural edgelighting is applied. A desk name plate, bevelled and inscribed on the reverse surface has brilliant edges and lettering when viewed from the uncut side.

DECORATION

The wide variety of possibilities for the decoration of Plexiglas can only be indicated in this manual. It is a field as great as the artistic ability of the person engaged in the art.

Many possible means of decoration have been mentioned in connection with other subjects in this manual. Machining methods, forming and cementing procedures are used, as well as coloring methods, both dyeing and painting. There are many variations and combinations of all the processes. A few will be discussed separately.

DYEING

Clear Plexiglas carries light practically undiminished and therefore produces great brilliance. Coloring or tinting the material naturally decreases the brilliance since some light must be absorbed by the coloring material. If the Plexiglas is surface-dyed, rather than colored all the way through, there is, of course, less diminishing of the brilliance.

A Plexiglas dye is simply a color dissolved in a liquid that will penetrate the surface but not seriously injure it. Great care should be taken to be certain the solvent of the dye does not harm the Plexiglas. Annealing the object before dyeing is a good policy since it removes surface strains which, if present, would be apt to develop a pattern of tiny fissures. This effect, called crazing, can best be seen by looking along the surface of the sheet. After dyeing it is well to anneal again to remove the tendency to craze caused by the dye.

Such precautions may seem excessive and certainly much dyeing is done successfully with no annealing. But the danger is always present and should be avoided when possible. The craftsman or small fabricator who has no annealing equipment should, when possible, dye the Plexiglas before forming it since the oven heat will help to anneal the stresses produced by the dye very well. In addition, care should be used throughout all machining and finishing operations to avoid generating heat that would result in stresses.

"Dip" dyes are popular with craftsmen. These are dyes that can be used, as the name implies, by simply dipping the object in the dye. The intensity of color is regulated by varying the time the Plexiglas is in the dye. The surface should be quite clean to produce a uniform color. Unpolished surfaces become more intensely colored than highly polished ones. When the desired color is obtained the object is removed from the dye, rinsed, dried and waxed.

It is best to do all the dyeing required in one operation. Crazing is more likely to occur if the Plexiglas dries between two or more separate dye dips.

A satisfactory mixture may be made with 60% acetone and 40% water. A dye is dissolved in the acetone, the water added, and the mixture filtered. A disadvantage of this type of mixture is that the dye precipitates due to evaporation of the acetone, weakening the color. For this reason, it is best to make up a stock solution in a large bottle and work from a small bottle which is refilled as needed from the stock solution.

Rub dyeing is a simple method of coloring Plexiglas in selected spots. A cloth dipped in the dye is rubbed on the area where color is wanted. (*Figures 74, 74a and 74b.*) A surface thus tinted appears vividly colored when viewed in such a way as to get internal reflection. For example, a rear surface bevel tinted in this way appears brilliantly colored when viewed through the front surface. The effect of irridescence is obtained when colors are mixed by rub dyeing.

After tinting, the object is rinsed, dried and waxed. The dyes will stay on the surface unless they are buffed off.

With either dip or rub dyes, a design can be colored, leaving the rest of the sheet clear, by carefully masking the sheet to outline the design.

Other dyeing processes will occur to the craftsman. Vividly colored edges can be produced by dissolving the dry dye in cement and painting the edge of the sheet. A cemented joint which might otherwise be distracting may be made decorative by tinting the cement used. An attractive effect is produced by laminating several sheets to build up a block of considerable thickness, using tinted cement. Such a block may be used in forming heavy parts such as lamp bases or massive box lids.

Mosaic or stained glass effects can be obtained by cementing shaped blocks of clear Plexiglas to a flat sheet, using different colored cements. The effects of jewel-like color and extraordinary brilliance, when viewed from the opposite side, make this a very promising technique for anyone with artistic imagination.

Grooves or other hard-to-reach places can be dyed by using an eyedropper or hypodermic needle to get the dye solution into the desired places and then tilting the Plexiglas to help the dye run down the markings as needed.

A surface that has been sanded, scribed or machined can be dyed by rubbing or dipping and then buffed to remove the color from the polished surface but not from the design. A loose, clean buff without tallow must be used to prevent building up tallow deposit in the design.

PAINTING

For many applications remarkably decorative effects are produced by using opaque paints. Many processes are used, but almost without exception the paint is applied to the reverse side of the Plexiglas, to be viewed through the transparent sheet. Seen in this way, the color appears brighter or richer—just as a painting takes on richer tones when it has been varnished.

Since the paint is to be viewed through the surface on which it is applied, the technique of application must, of course, be different. The "top coat" must

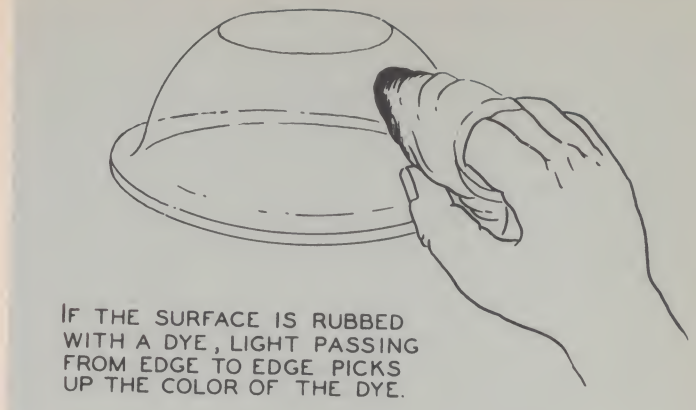


Figure 73

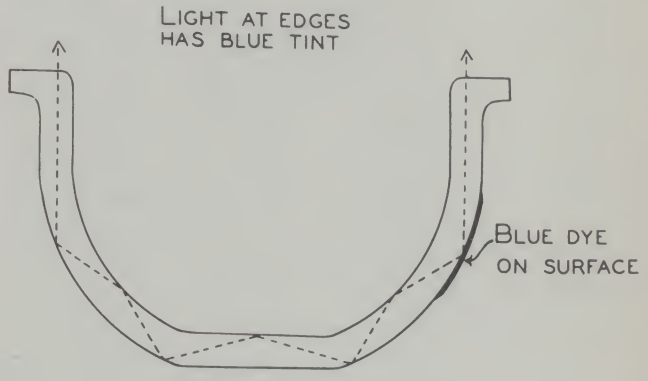
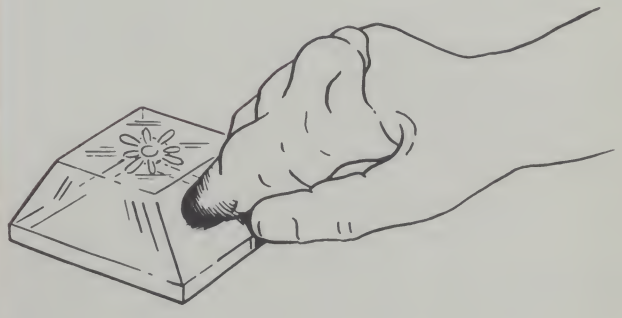


Figure 74



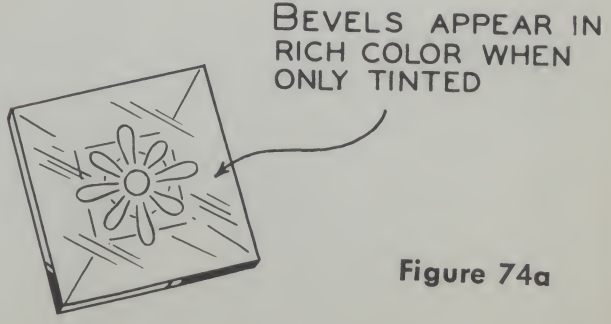


Figure 74a

be applied first, followed by such undercoats as may be desired. Naturally, there can be no correction of color or appearance after the paint is applied, since the "top coat" is inaccessible.

The problem of crazing, discussed in connection with dyes, is also present with paints. Solvents and driers in paints are likely to attack the Plexiglas surface and cause crazing, but unless there is some surface action of this type it is difficult to get a good bond between the paint and the Plexiglas. Annealing is recommended in paint processes just as it is in dyeing. The craftsman wishing to use some paint decoration without the bother of the full technique will find that the danger of crazing is reduced when paint is applied and then left untouched. Processes requiring removal of portions of the paint are more uncertain.

On polished Plexiglas oil paints or lacquers seem to be most satisfactory—water base paints do not adhere well. On machined or sanded surfaces, show card colors, tempera and other water-base paints are satisfactory. Show card color, for example, is ideal for use where a scribed or carved area is to be painted and the polished portion left clear. The color is applied freely over the area and then wiped from the polished surface, leaving the design colored.

Paint may be applied by brushing, flowing or spraying. When it is brushed on, care must be used to avoid leaving brush marks, for, seen through the Plexiglas surface, irregularities are especially distracting. When the Plexiglas part is such that it can be held at an angle and the paint flowed on, the danger of brushmarks is, of course, eliminated.

Spraying is often a better means of application than either brushing or flowing. It is usually faster and, when skillfully done, a very even coating is obtained. The surface should be free of lint or dust to avoid the formation of pin holes. If pinholes do appear, they can usually be corrected by allowing the paint to dry and then rubbing the dust particle off with the finger tips. A second application of paint will then fill in the hole.

Small areas may be sprayed with an atomizer or air brush. The air brush is a tool of the artist and can be made to produce beautiful gradations of color, but requires considerable practice for most craftsmen. Large areas of Plexiglas are best painted with a regular spray gun such as is used for much commercial painting. In any spraying operation, but especially when the spray gun is used, care is necessary to avoid the formation of sizeable droplets which would create an uneven effect.

Most painting operations will require masking. The areas to be protected can be covered readily with pressure-adhesive masking tape or frisket paper, care being taken to rub down the edges well so paint doesn't seep under the tape. In some cases the entire sheet may be masked and the design cut out with a razor blade. In others, the scratching produced by this method is undesirable and the design will have to be cut out on a separate surface and then applied to the Plexiglas. When several colors are desired, mask patterns for each color will be necessary, one applied after the other, allowing time for the paint to dry between each coating. Usually the paint applied first can be covered by the next color without changing the effect of the initial coating.

An interesting variation in the process of decorating with paint consists of reversing the order of application. The background color is applied to the Plexiglas first and allowed to dry. Then with orange stick or Plexiglas point, the color is scraped off where a design of different color is desired. This area is painted with the new color, allowed to dry, and space for another color scraped away. The process can, of course, go on indefinitely to make whatever design is wanted. A sketch of the completed picture, placed under the Plexiglas, while the decorating is in progress can be used as a guide, since it becomes visible in the section being worked as the paint is scraped away, the only difficulty being in locating the proper point to start the scraping. A more accurate but somewhat more complicated guide would be a cut-out pattern laid on the back of the sheet, directly on the painted surface.

The method just described is used in modified form in many commercial applications. A design is molded or carved into the back of a Plexiglas object and the various portions are painted different colors, producing a colored relief that appears to be imbedded beneath the smooth crystal surface. Light colors are recommended for this process, since the relief is partially lost in the shadows when shades are used. Best of all are the metallic paints which bring out both highlights and shadows remarkably well.

OTHER METHODS

The processes of decorating Plexiglas which have been described are selected as examples of some which have been found effective. There are many variations and combinations of these processes, and new methods are still appearing. One interesting process is inscribing—an operation similar to dry-point etching. A sharp-pointed stylus is used to scratch out the design on the Plexiglas, working free-hand or aided by straight-edge and curve. Light areas are cross hatched easily. Inscribed decorations are viewed through the Plexiglas and, when edgelighted, are remarkably crisp, sharp and brilliant. Color may be applied with dye or paint by the rub-off method previously described.

Another method of decoration mentioned previously, is grooving. This is most conveniently done on the table saw and is, of course, limited to straight lines. Parallel grooves, checkerboard designs or plaid patterns are possible, and by varying the depth, width

and colors of the grooves, great flexibility of design is possible. Slanting grooves, produced by setting the saw at a sharp angle make particularly interesting variations of the process.

When cutting grooves on the saw, the Plexiglas sheet should be masked, since the surface of the plastic would scratch badly if it were unprotected while being moved back and forth on the saw table.

Many home craftsmen will be interested in carving Plexiglas. It is not carved with a knife or chisel, as in wood carving, but is scraped away, being worked in much the same manner as brass. Small, pointed tools and variously shaped scrapers are used for the purpose. With such tools, Plexiglas may be carved as desired, but the operation is exceedingly tedious and has only limited use.

Machine carving, on the other hand, is fast, comparatively easy and has wide application. A great deal of carving is done with small hand-held motors driving drills, cutters and burrs. A flexible shaft is preferable to the hand-held motor in many ways, but the shaft handicaps the movement of the worker somewhat.

A drill press can be used for some work, the spindle being clamped and the Plexiglas moved on the revolving drill. A chuck in the lathe headstock may also be used, and because of its horizontal position is often somewhat less awkward. Table routers, (*Page 14*), equipped with round headed, tapered or straight bits are very useful for many operations and are quite fast, although they are more dangerous than the other carving devices. The router is very useful in making texture patterns, especially useful in box bases where the plain Plexiglas would be quickly disfigured by scratching. (*See Figure 75.*)

These same tools are used for intaglio carving, which is simply backward relief on the reverse side of a sheet. Intaglio is far more effective than surface relief. A shaded drawing may be changed into actual relief by intaglio carving. If edgelighting is to be used, the carved surfaces should not be polished; the silky texture left by the machine is more pleasing.

INTERIOR CARVING

Interior carving is the name given to a technique that has been found particularly well adapted to Plexiglas. The effects obtained are startlingly beautiful and do not require either long training or great craftsmanship to produce. Interior carving consists of boring into a sheet with burrs or sharpened drills. By moving the tools from side to side or back and forth, a cavity of any desired shape is cut out. Flowers, leaves, fish, animals, landscapes and any appropriate designs can be made this way. When the carving is completed and the cavity cleaned of shavings, it can be left open or dyed and filled with plaster. The completed piece has the appearance of an object imbedded in the Plexiglas.

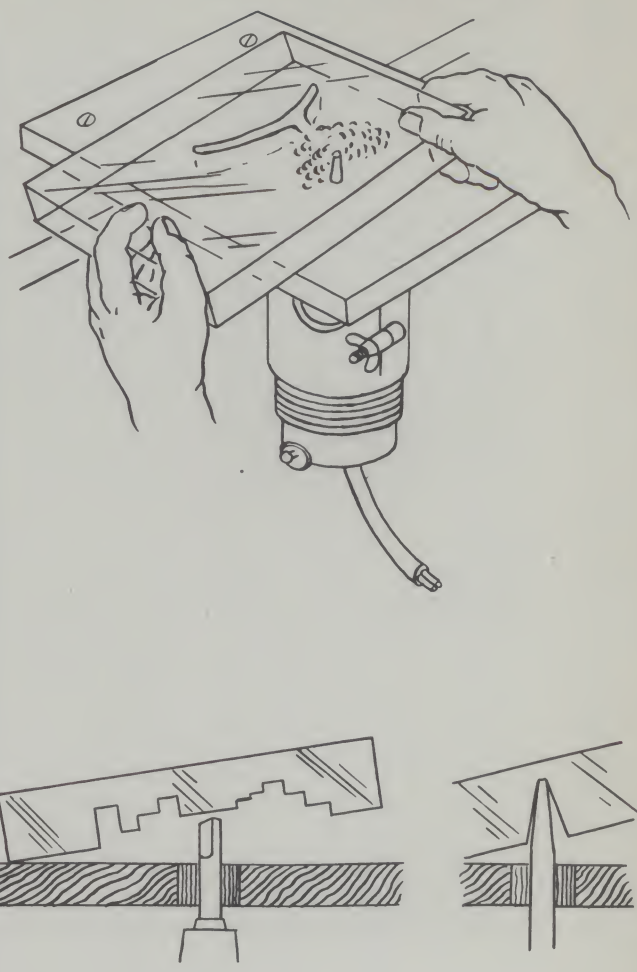


Figure 75

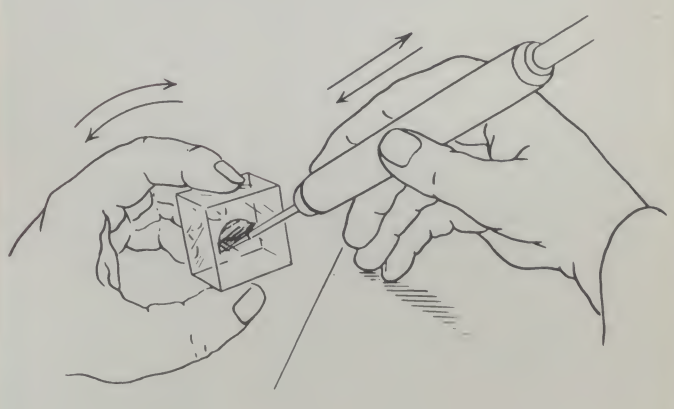


Figure 76

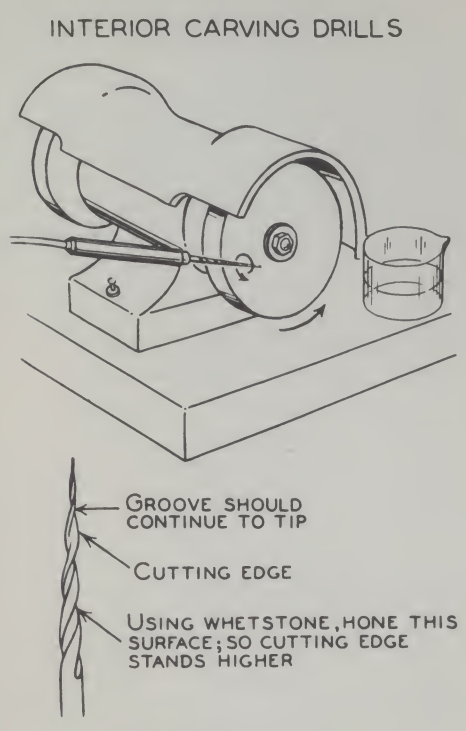


Figure 77

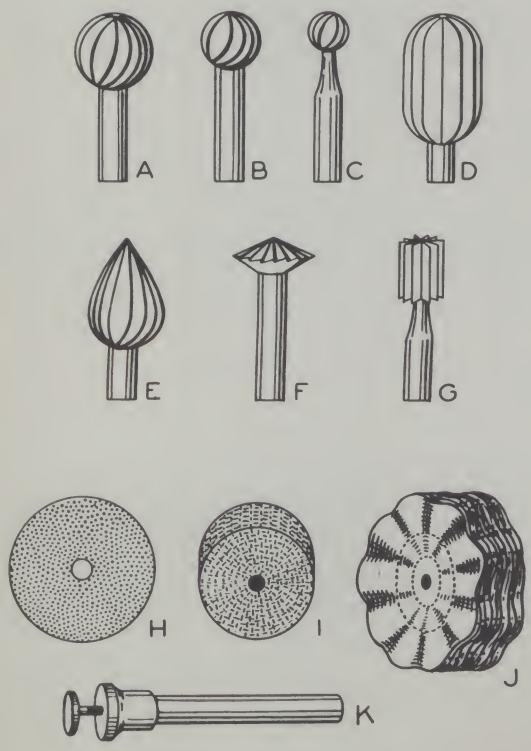


Figure 77a

There is no "right way" to hold the tools for interior carving. What seems easiest to an experienced carver is to hold the instrument as a pencil, resting the side of the hand or the last two fingers on the table top to guide and steady the hand. The movement of the instrument is up and down. Sideways movement is produced by moving the work back and forth. (*See Figure 76.*)

Figure 77 shows how a drill should be sharpened for interior carving, while a few sample burrs and cutters are illustrated in Figure 77a. Each of these cutters is used to produce a desired effect. The long tapered drill, for example, shown in Figure 77 is used to produce a leaf. (*See Figure 82*), or a rose *83* and *84*. This drill in combination with a cylindrical burr is used to produce small flowers (*Figure 81.*)

Burrs A, B, C and D shown in Figure 77a are excellent for carving out rounded forms. Finer ones such as those used by dentists are good for finer scale work.

Burr E is used for tapered shapes such as rose buds.

Burr F will be found useful for surface carving such as stems, leaves and conventional designs.

Burr G, held at a 45° angle, makes a variable 90° groove. This burr will be found useful for surface carving of grass, wheat, etc.

The mandrel K, sanding disc H, felt buff I and cloth buff J are used for finishing in difficult corners.

When an interior carving has been completed, it can be dyed and filled so that it appears as a solid object in the Plexiglas, or it may simply be cleaned of shavings and left translucent. Still another effect is produced when the piece is dyed but not filled.

The dyes to use already have been described in "dyeing." It is important that the shavings should be removed from the cavities. This may be done by running through the holes a second time with the drill. Shavings left in the holes may either block the dye or collect it by capillary attraction and make intense spots of color. An eyedropper or hypodermic needle may be used to fill the holes and keep the colors from running from one cavity into the other.

If a flower is to be made with petals of one color and the center of another, first bore out the center and dye that. Then make the petals, dye them and fill with plaster of Paris. (*Figures 78, 78a, 79, 79a, 80 and 80a.*) For a yellow center in a white flower, it is best to make and dye the center first so that the dye does not run into the petals. To get the tips of a flower of one color and the petals another, first fill with the tip color and pour it out. Capillary attraction holds the dye at the petal edges and the second color then dyes the rest of the petals. To grade a color, use 60-40 acetone and water mixture to fill the first part and then add ordinary dye to fill the rest of the cavity. Pumping the eyedropper will mix the clear and colored parts, producing a gradation. To get a very shiny

surface, fill the cavity with solvent cement and pour out immediately, so that only the surfaces are "solvent polished." The design can then be dyed and the cavity filled. The effect can be quite decorative, but it destroys the machined texture which adds to the realistic appearance of a flower.

After coloring, the flowers can be filled with plaster. Plaster of Paris will set in the acetone dye so that it is not necessary to pour out the dye and replace it with water. The dry powder is poured in a heap over the cavities and the object tapped on a padded surface so that the jarring carries the plaster to the bottom of every cavity. As the cavities are thus filled, dry plaster is added and rubbed off to fill the cavities up to the surface. In two or three days the drying plaster will shrink from the walls of the cut leaving a very attractive "pearly" appearance on the carving.

With all these methods of decoration and many more not mentioned, a hobby of decoration alone could be evolved. In general, a decorative scheme that enhances an object, as in design, is one fitted both to the object and the material used. Daisies on a man's billfold won't do; on a powder box they are quite in place.

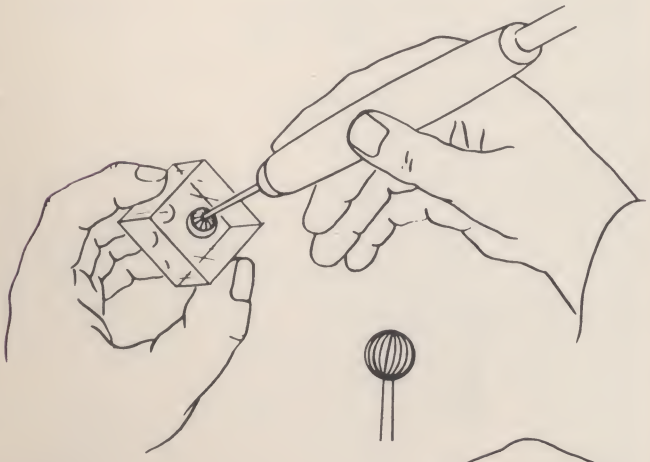
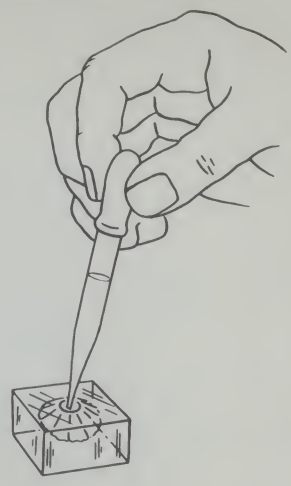


Figure 78

Figure 78a

DYE CENTER OF FLOWER YELLOW

Figure 79



FILL WITH WATER AND SHAKE OUT AIR BUBBLES

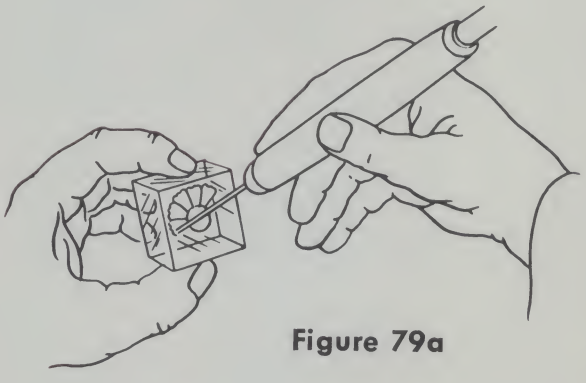


Figure 79a

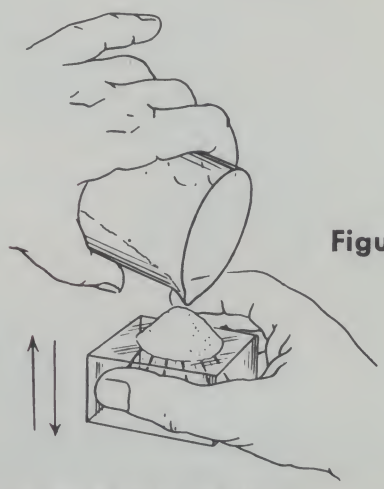


Figure 80

POUR DRY PLASTER OF PARIS IN HOLE. TAP ON A FLAT SURFACE TO FILL CAVITIES

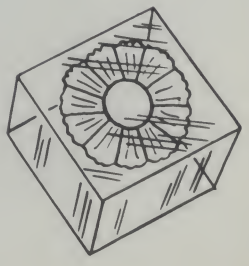


Figure 80 a

FINISHED DAISY

Figure 81

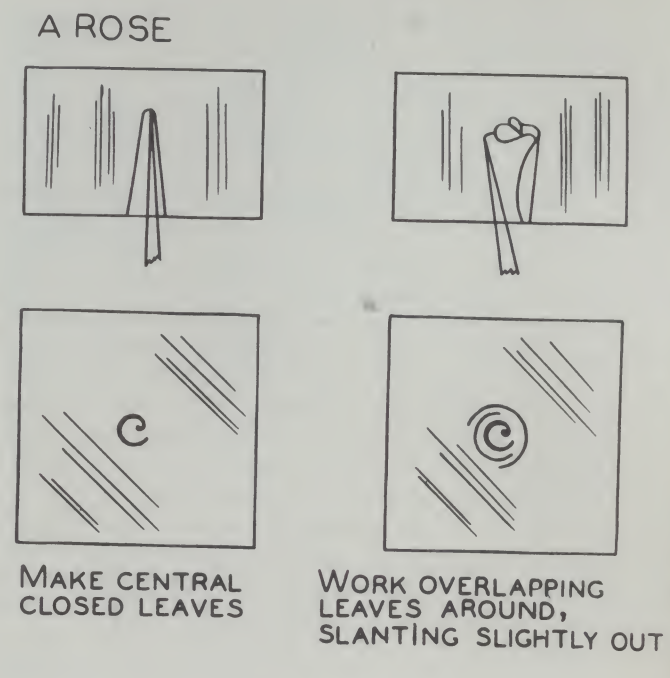


Figure 83

Figure 82

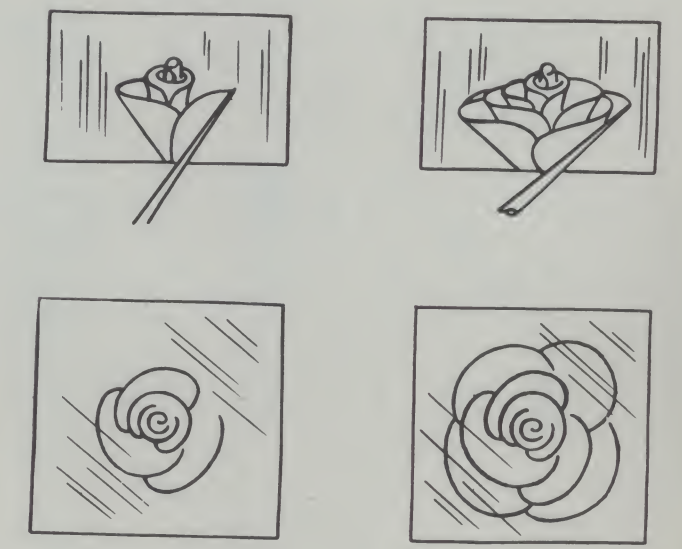
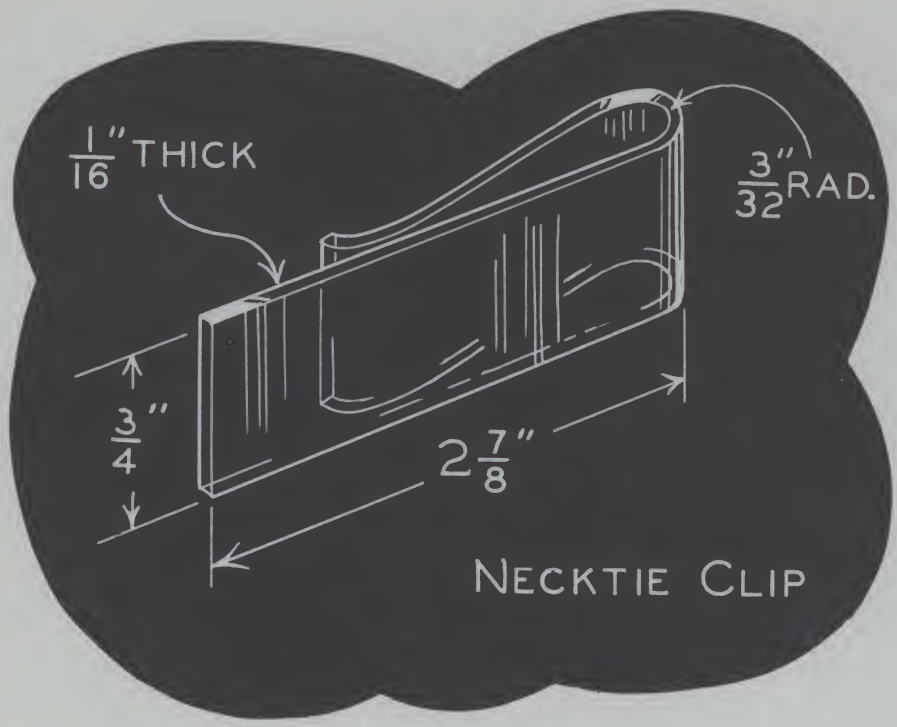


Figure 84

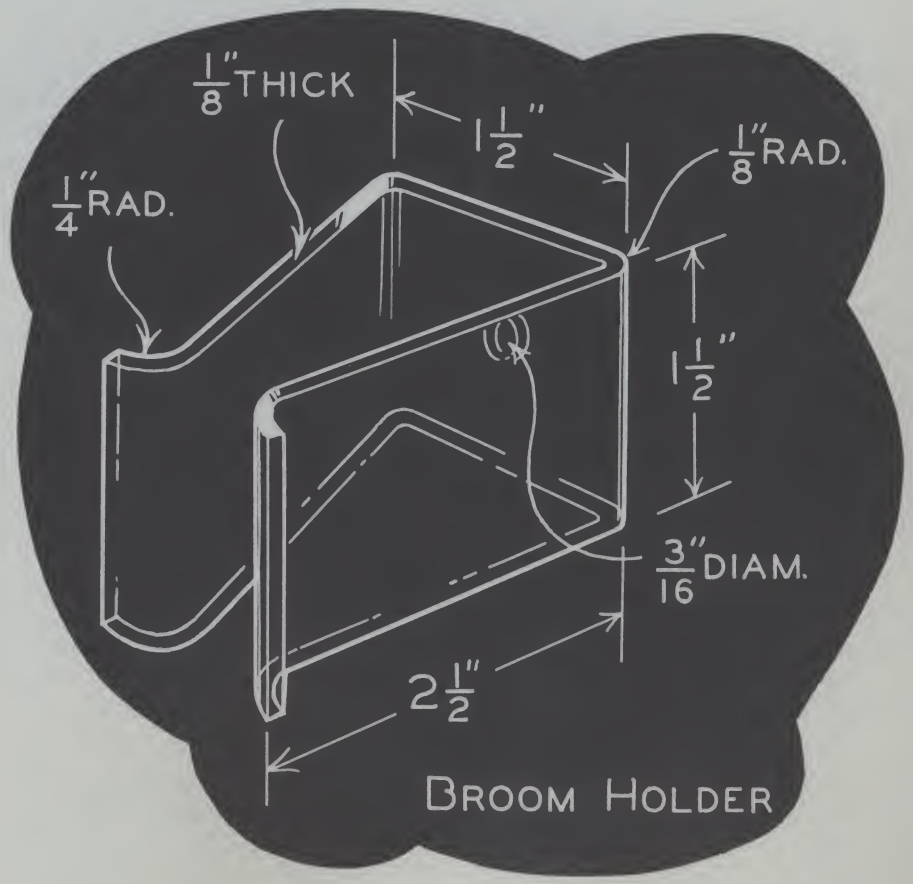
PROJECTS TO MAKE

THE CRAFTSMAN who works with Plexiglas will find there are practically no limits to the number of useful or decorative items he can make in his shop. Plans for a few typical designs are reproduced on the following pages.

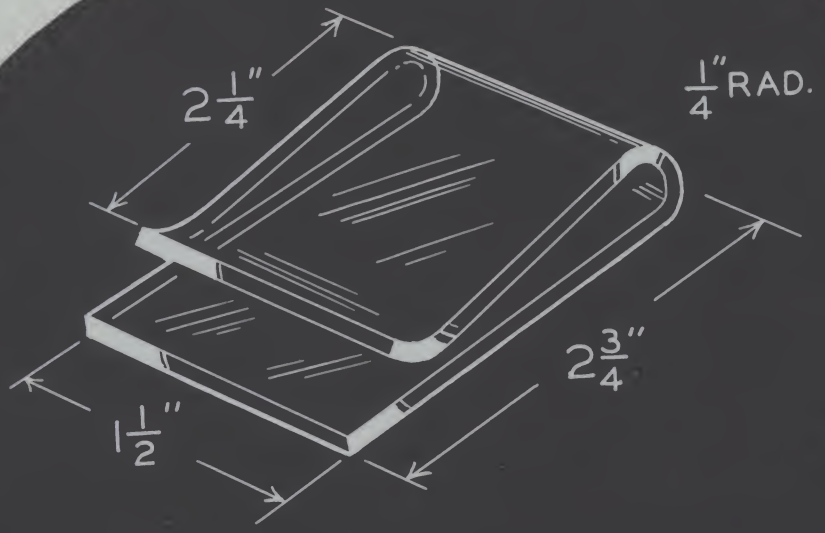
From these very simple designs, aided by the discussions of the preceding pages, the Plexiglas fabricator may extend his work as he desires. He will find, as he gains experience in manipulating Plexiglas, only the boundaries of his own imagination limit his designing new projects.



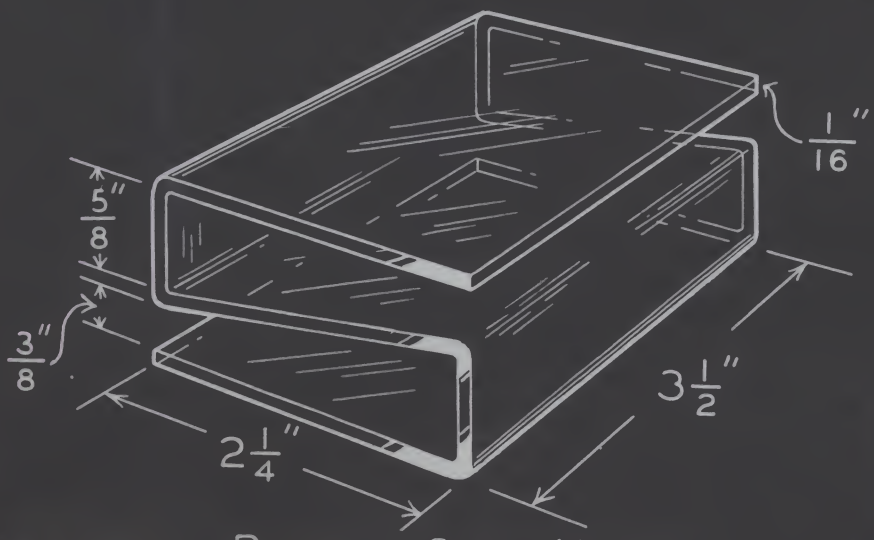
NECKTIE CLIP



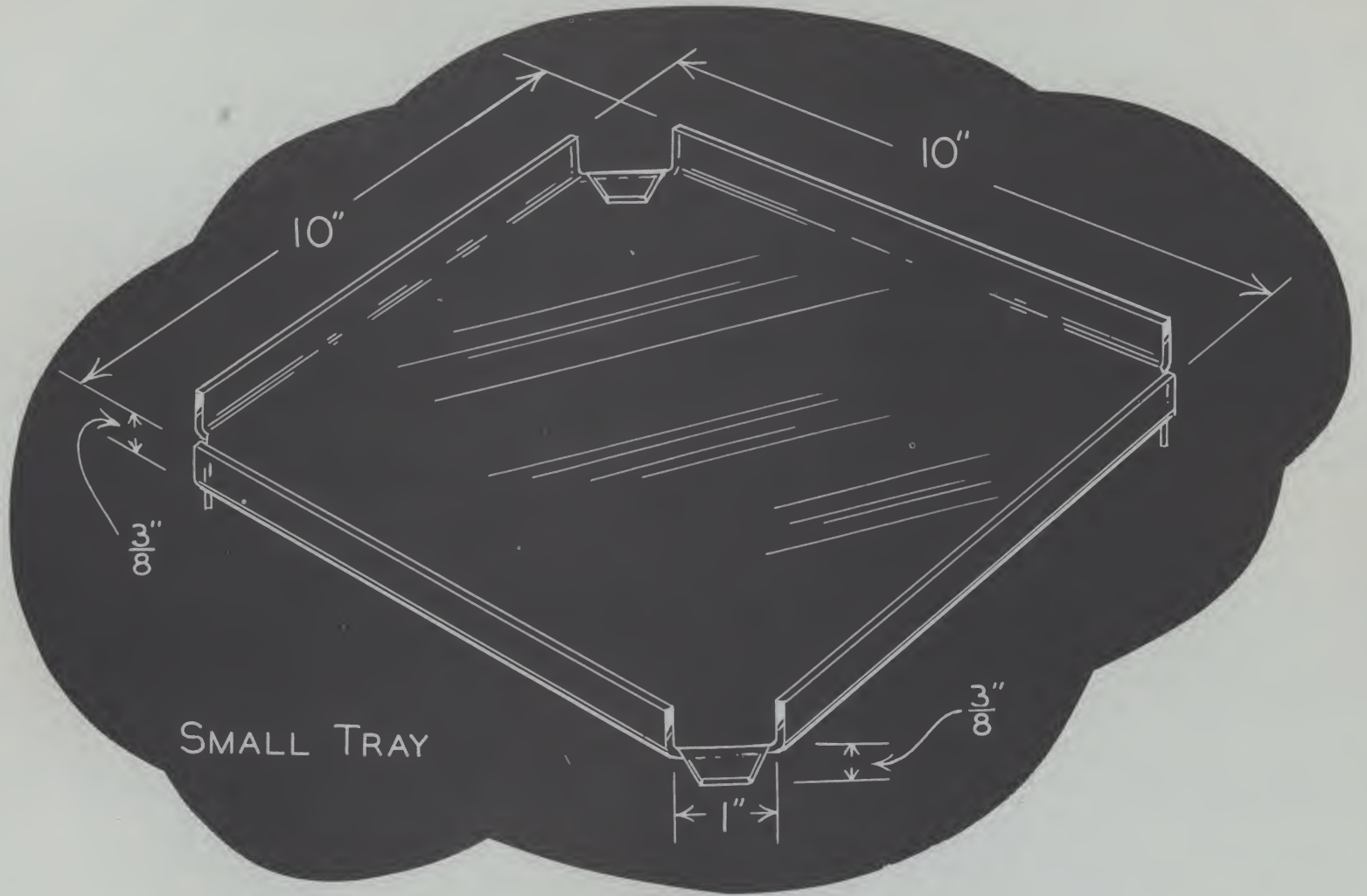
BROOM HOLDER



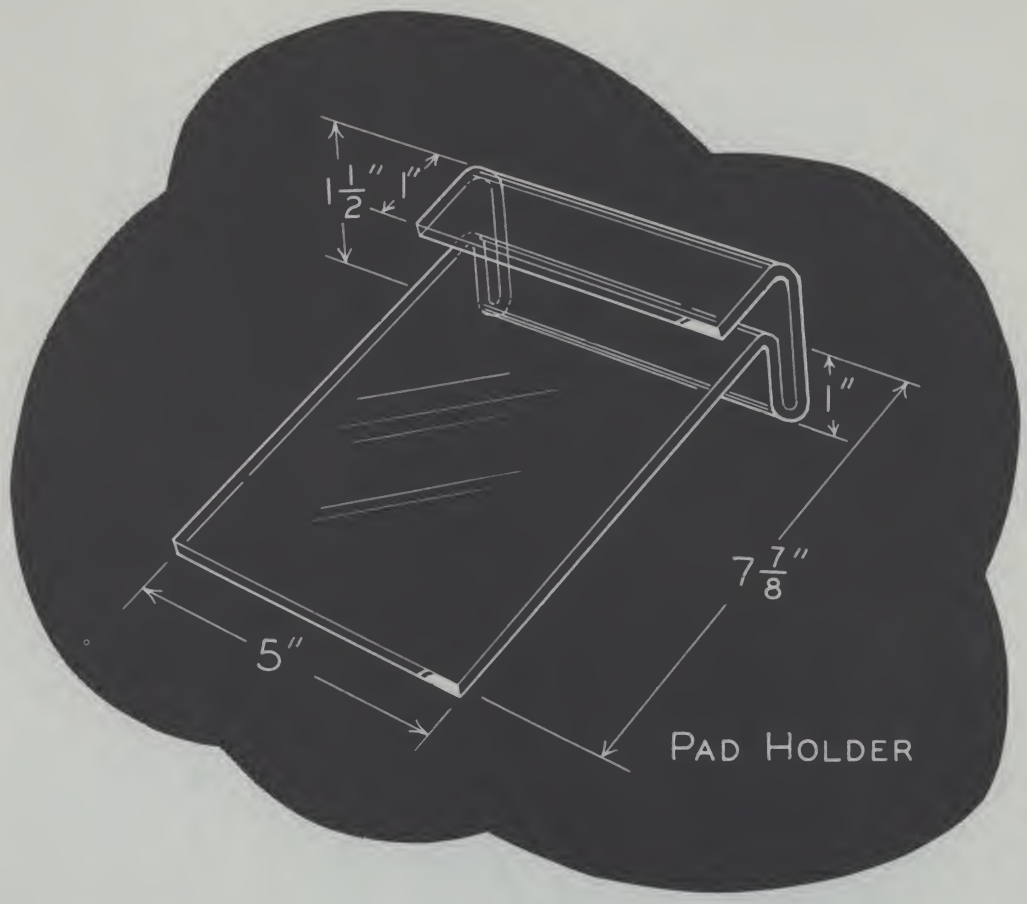
CLIP FOR MONEY OR CARDS



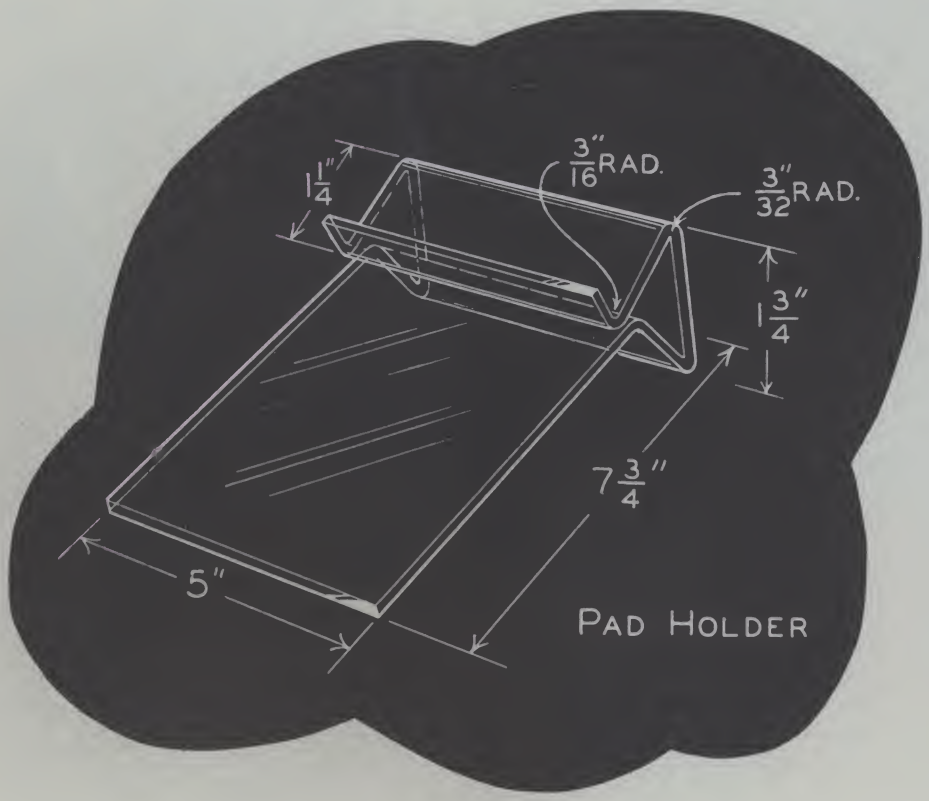
PLAYING CARD HOLDER



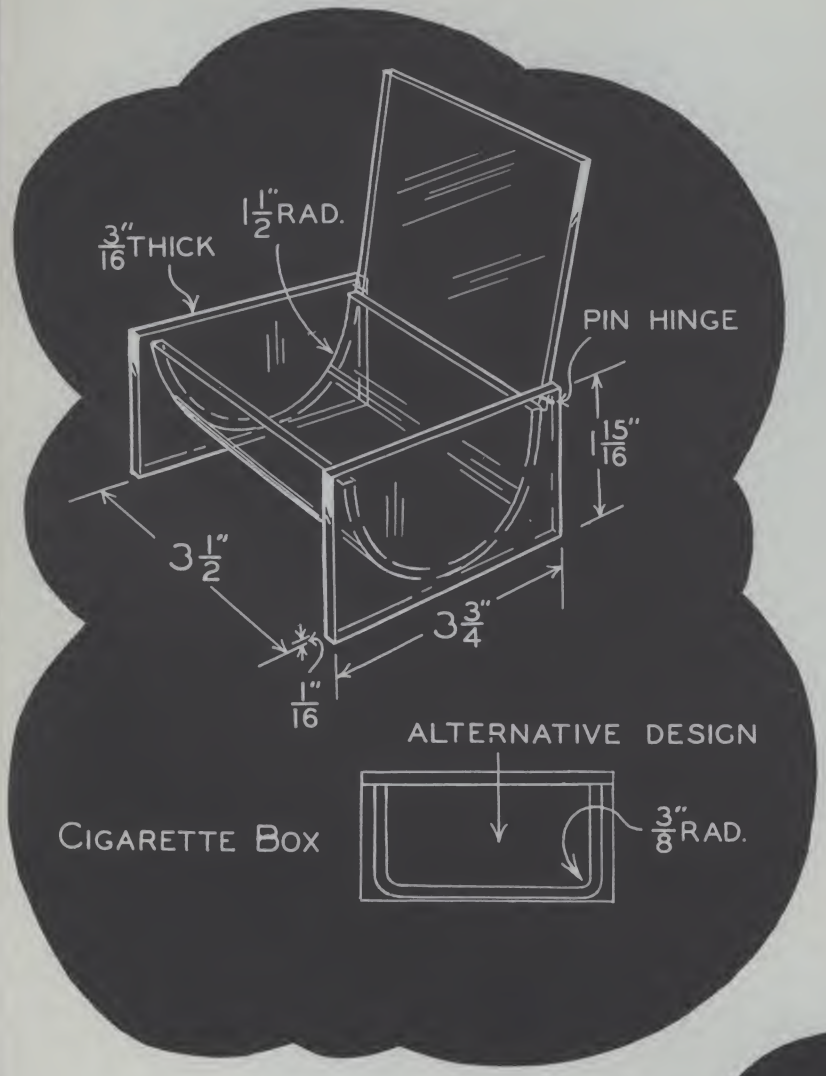
SMALL TRAY

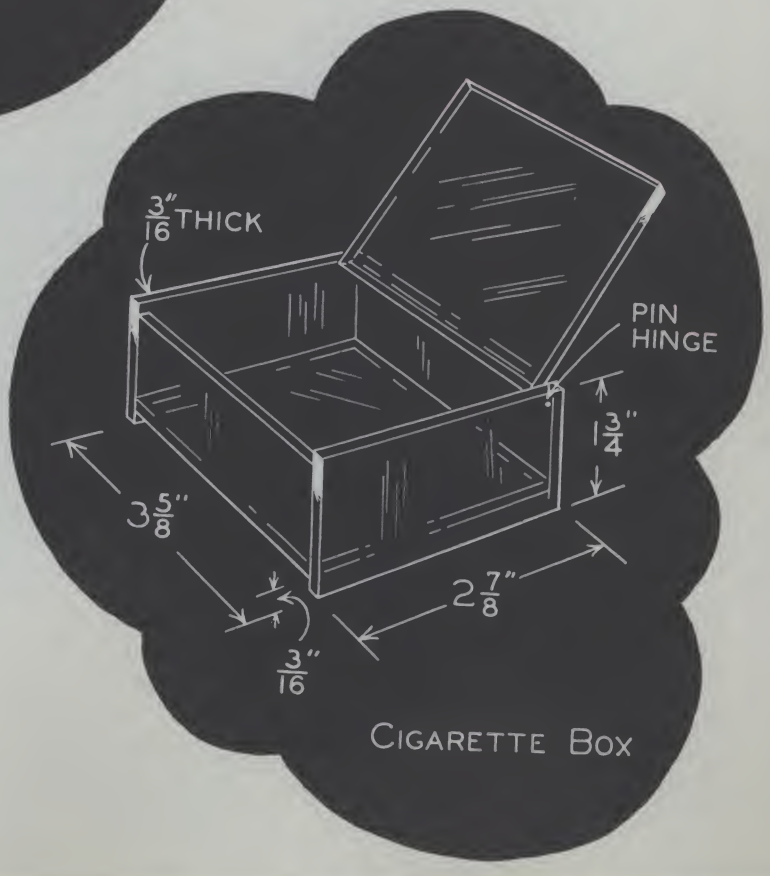


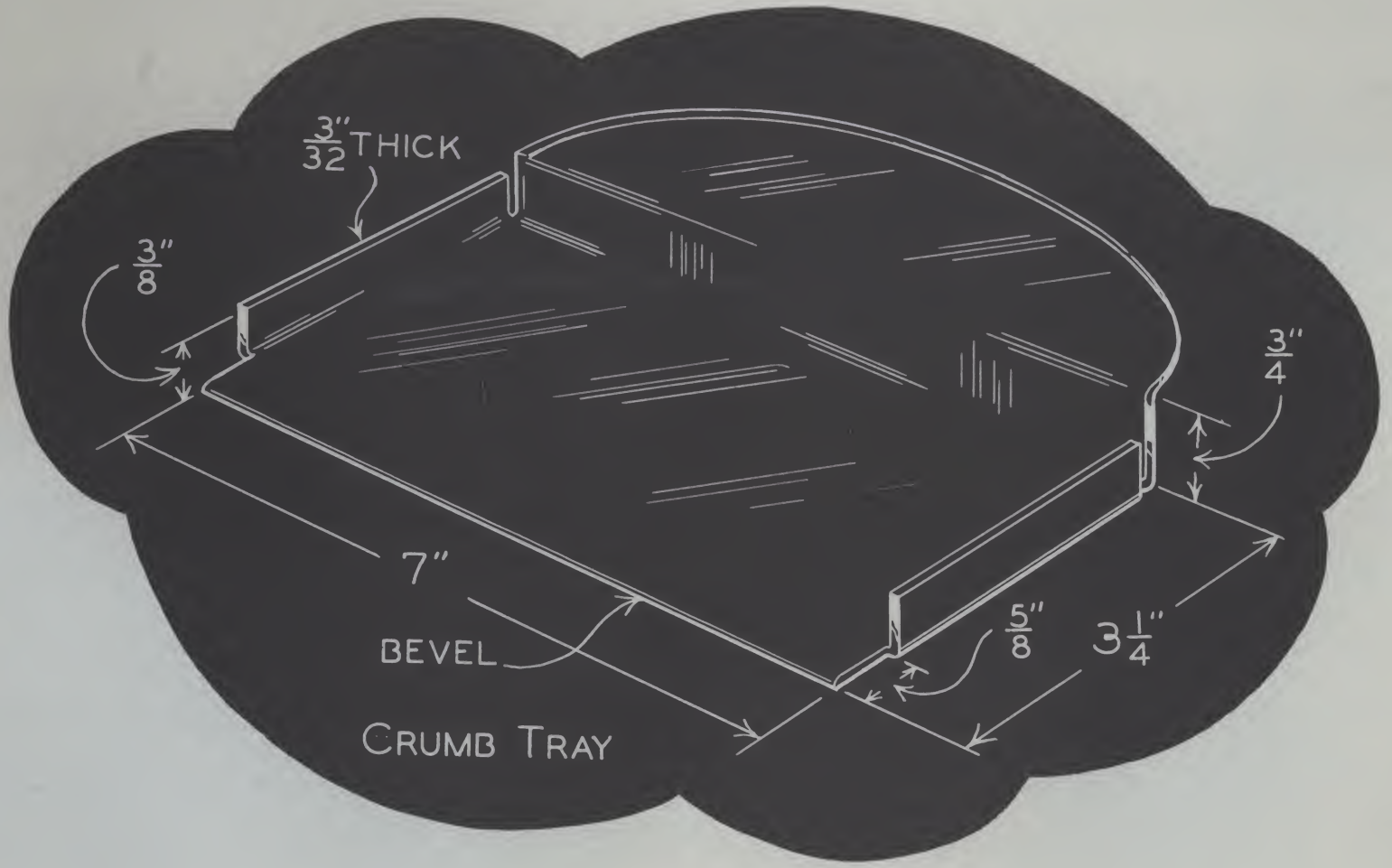
PAD HOLDER

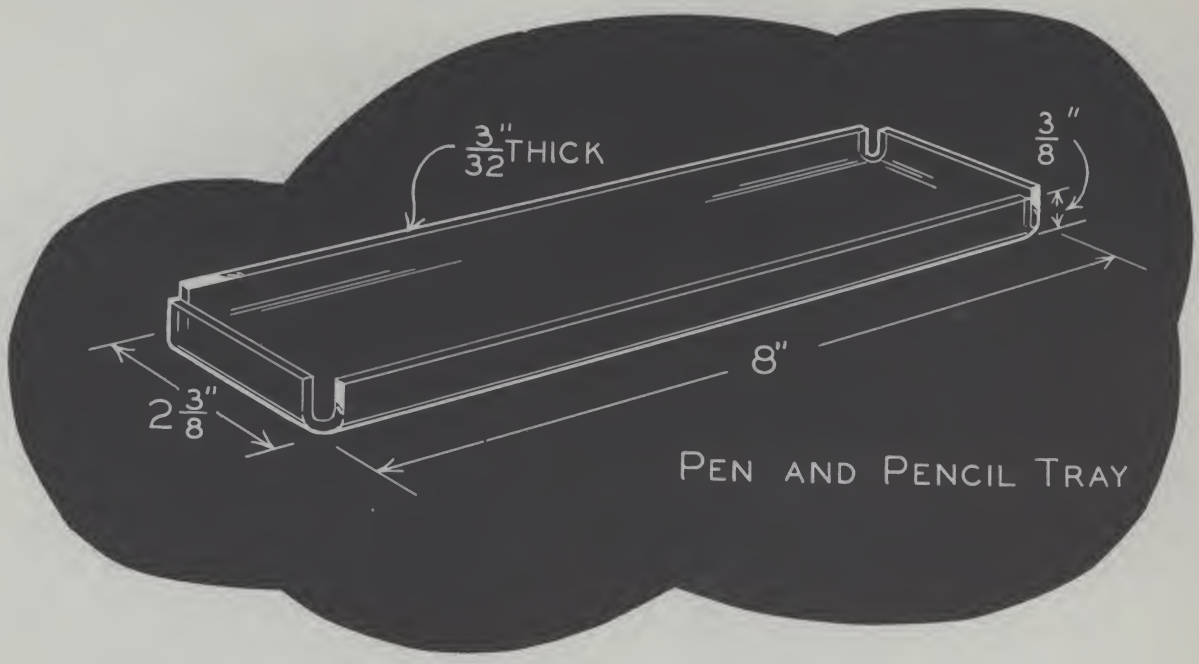


PAD HOLDER

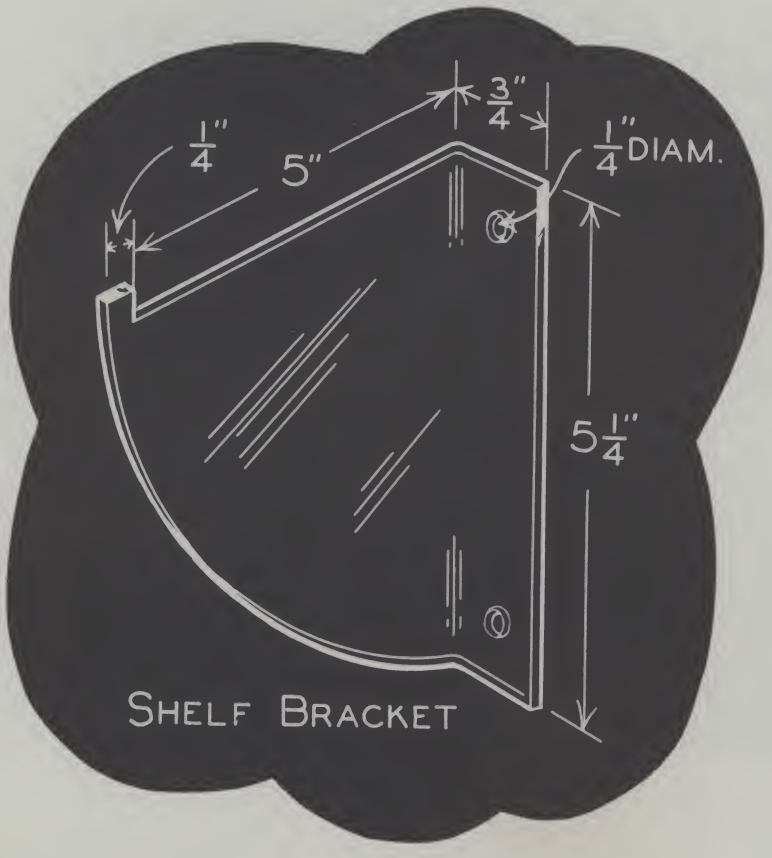

3/16" THICK
1 1/2" RAD.
PIN HINGE
1 15/16"
3 1/2"
3 3/4"
1/16"
ALTERNATIVE DESIGN
3/8" RAD.
CIGARETTE BOX


3/16" THICK
PIN HINGE
1 3/4"
3 5/8"
2 7/8"
3/16"
CIGARETTE BOX

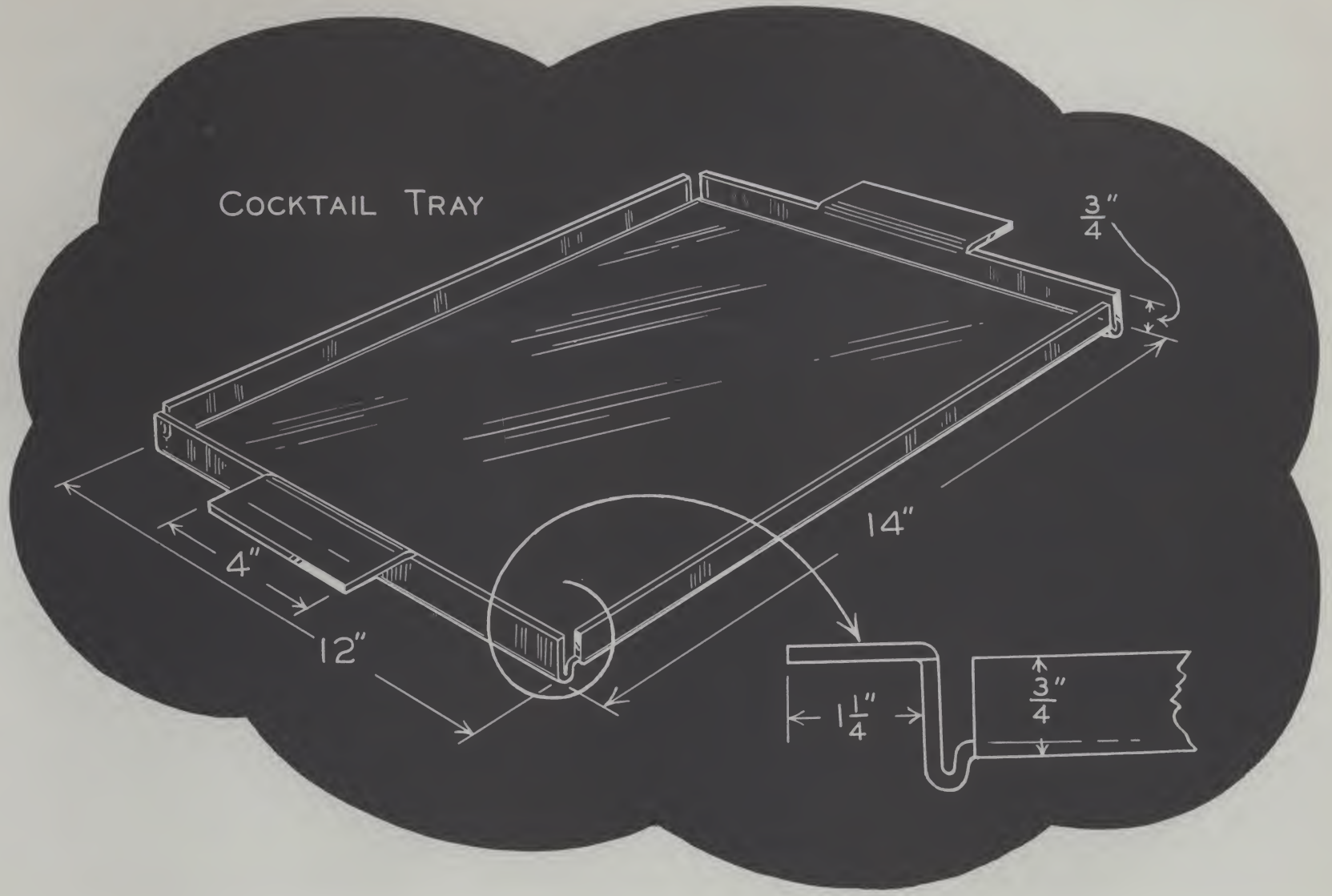

3/32" THICK
3/8"
3/4"
7"
BEVEL
5/8"
3 1/4"
CRUMB TRAY

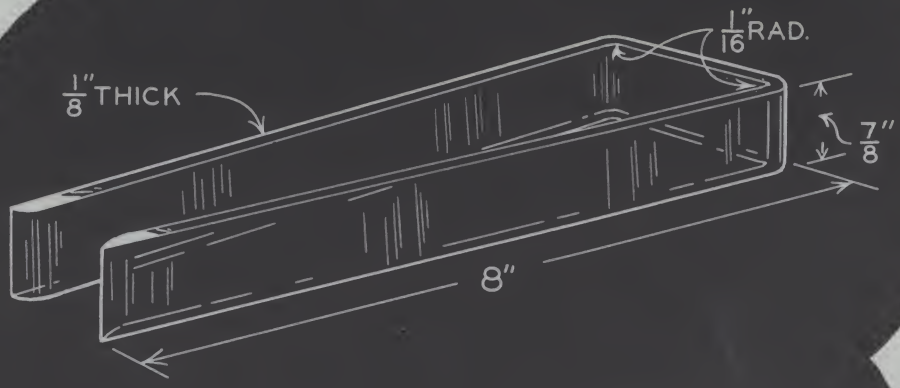


PEN AND PENCIL TRAY

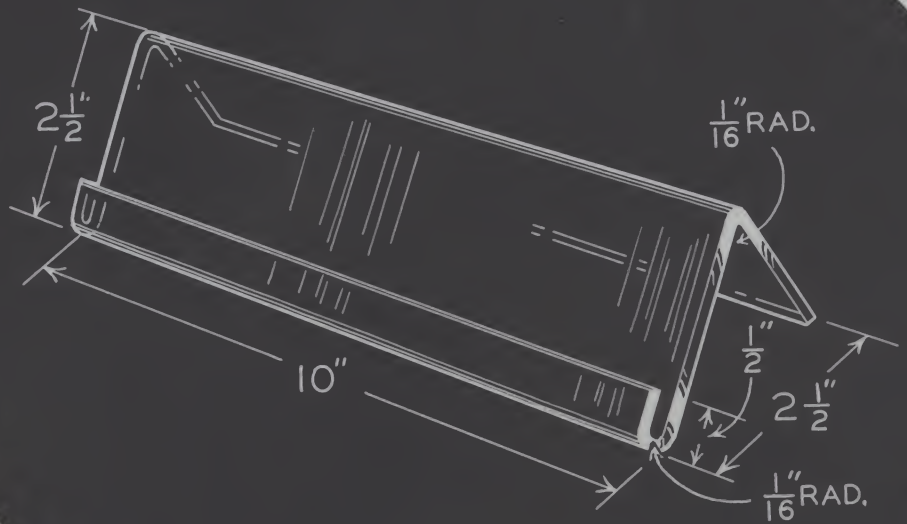


SHELF BRACKET

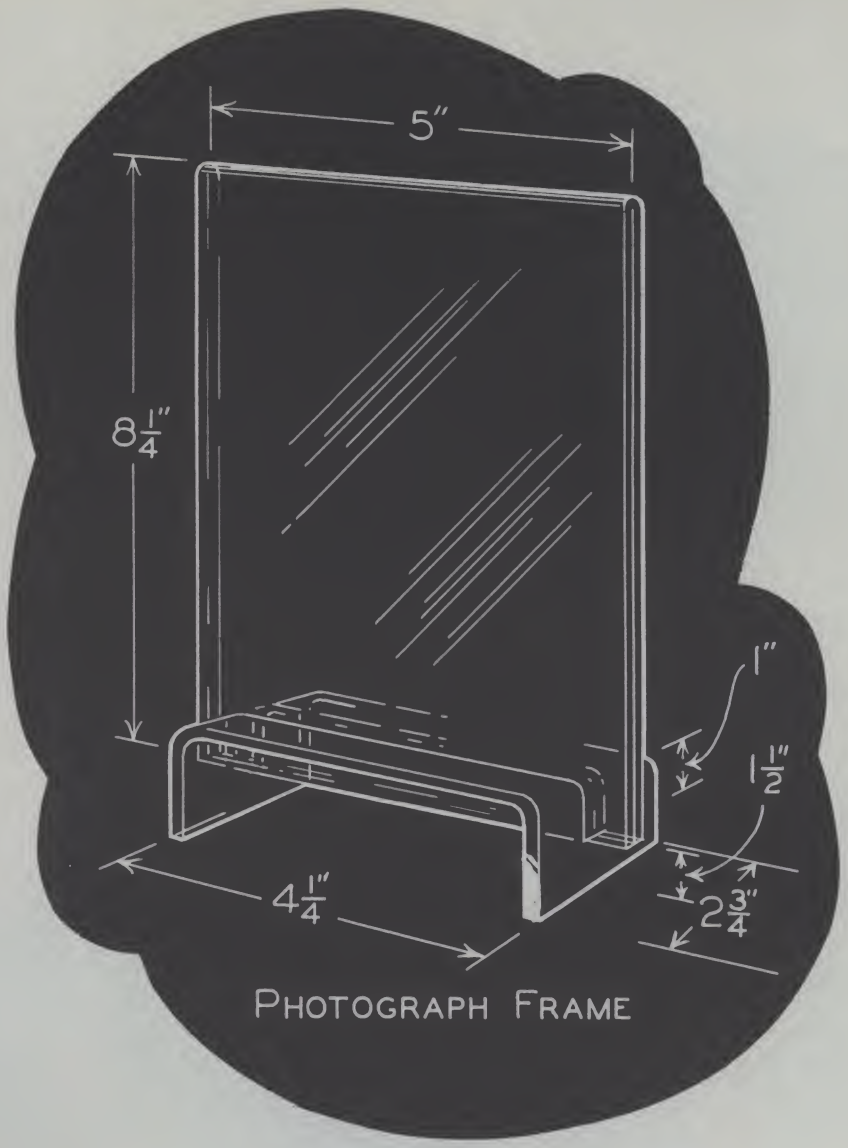

COCKTAIL TRAY
3/4"
14"
4"
12"
1 1/4"
3/4"



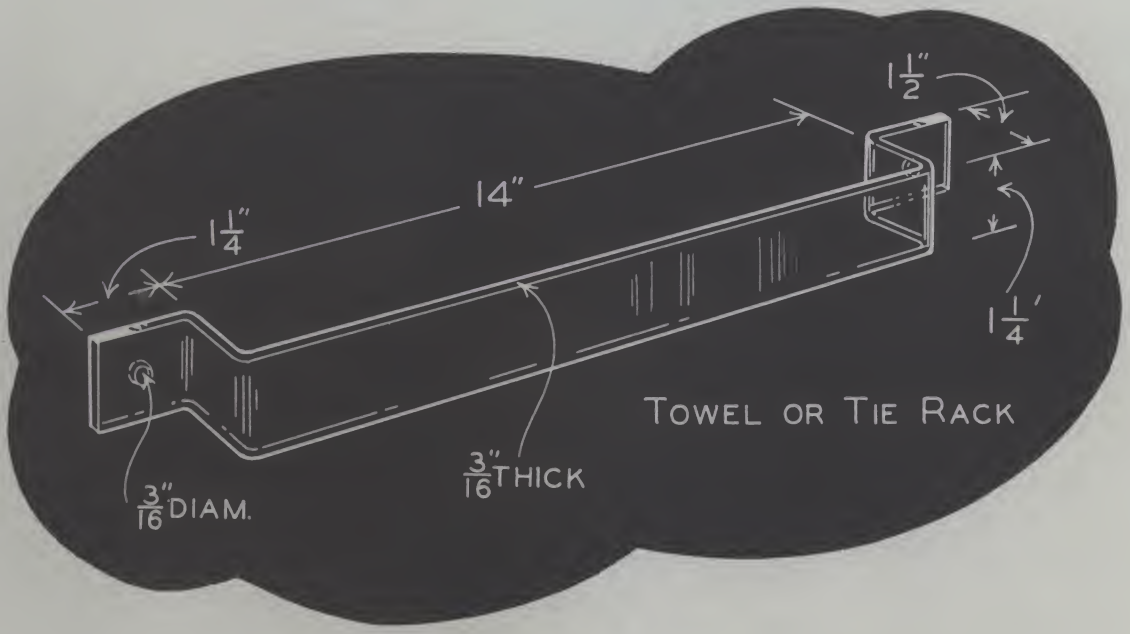
SALAD AND CANAPE TONGS



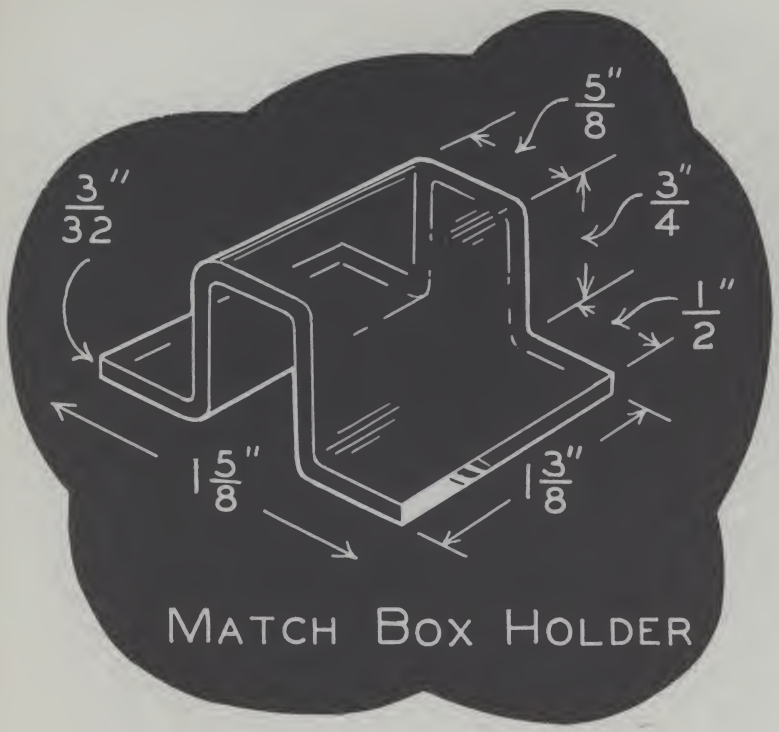
PLAYING CARD HOLDER
FOR ONE ARMED PLAYER



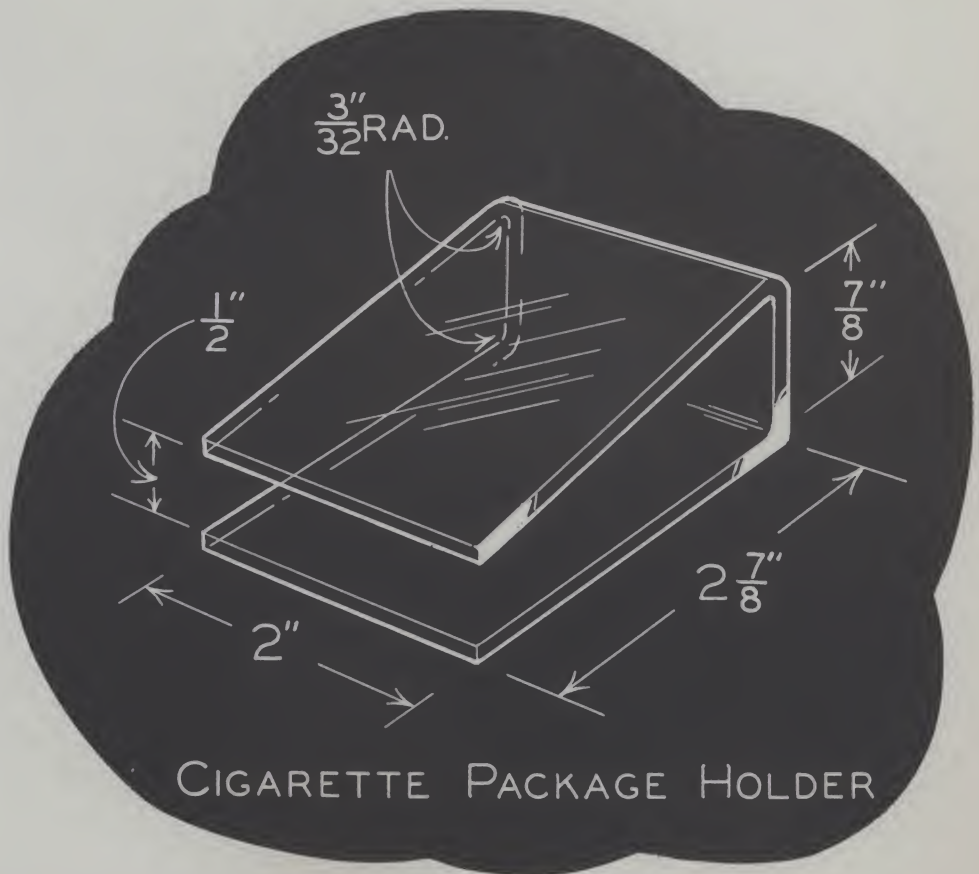
PHOTOGRAPH FRAME



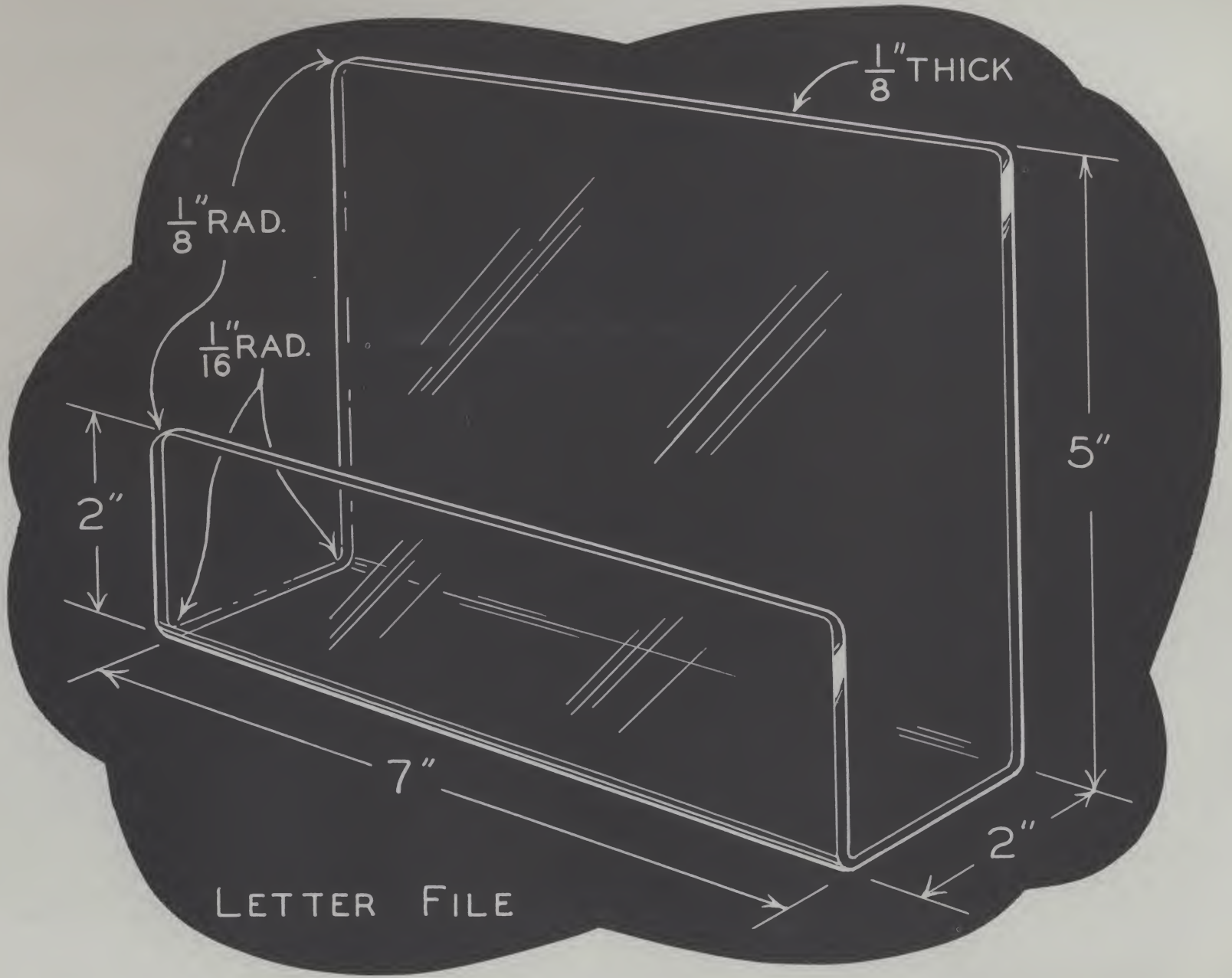
TOWEL OR TIE RACK



MATCH BOX HOLDER



CIGARETTE PACKAGE HOLDER



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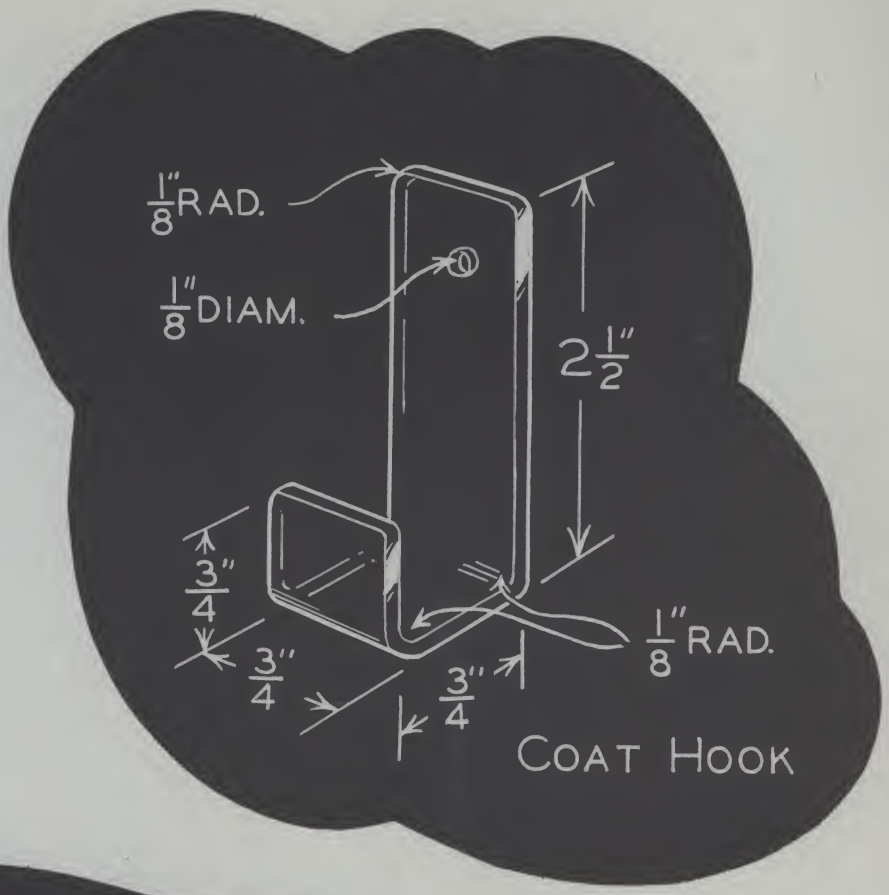
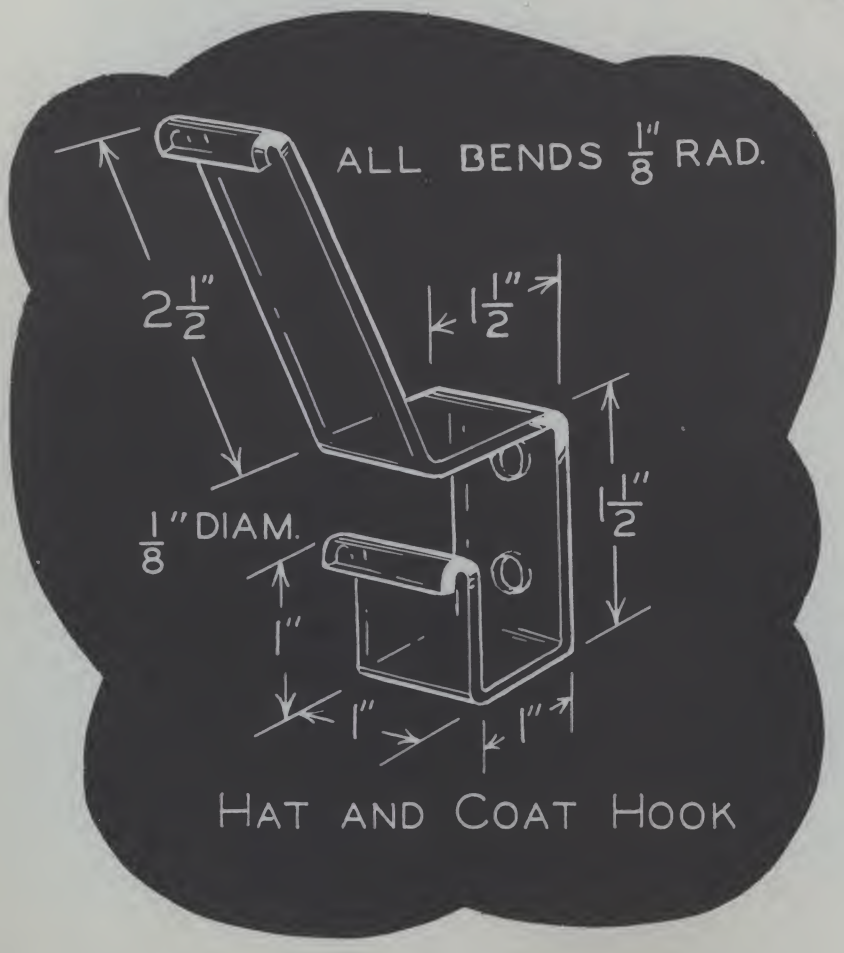
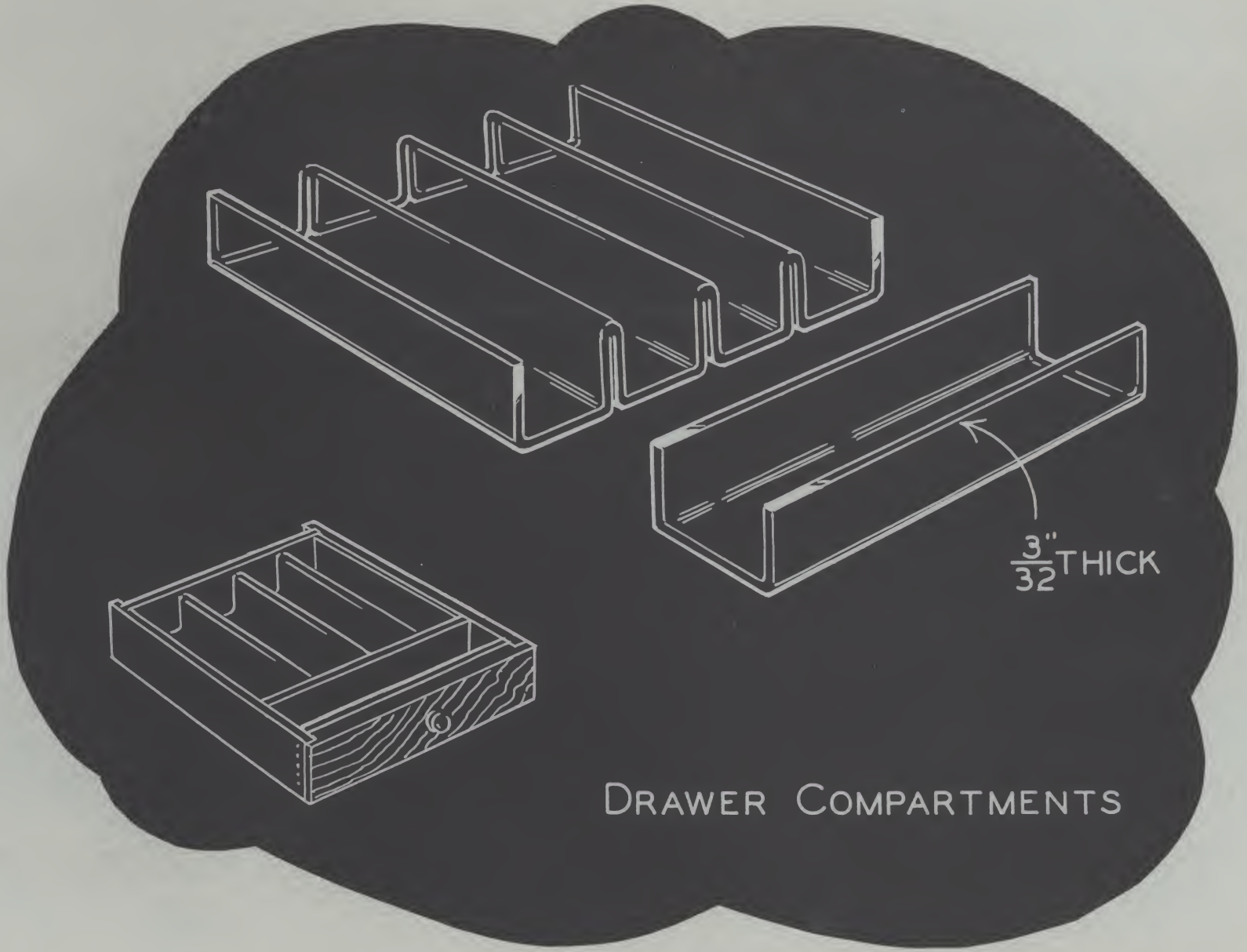


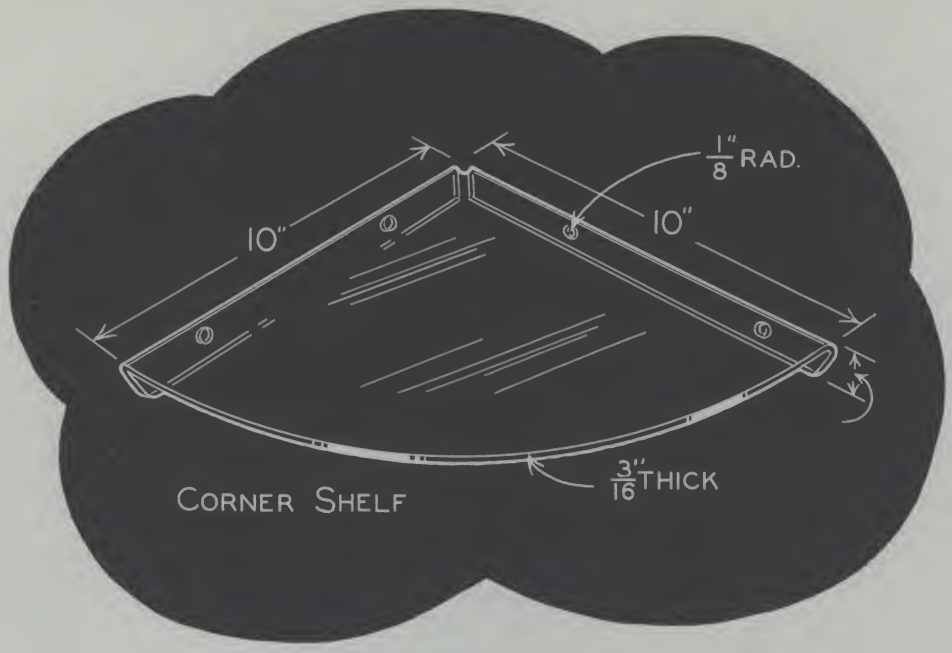
COAT HOOK



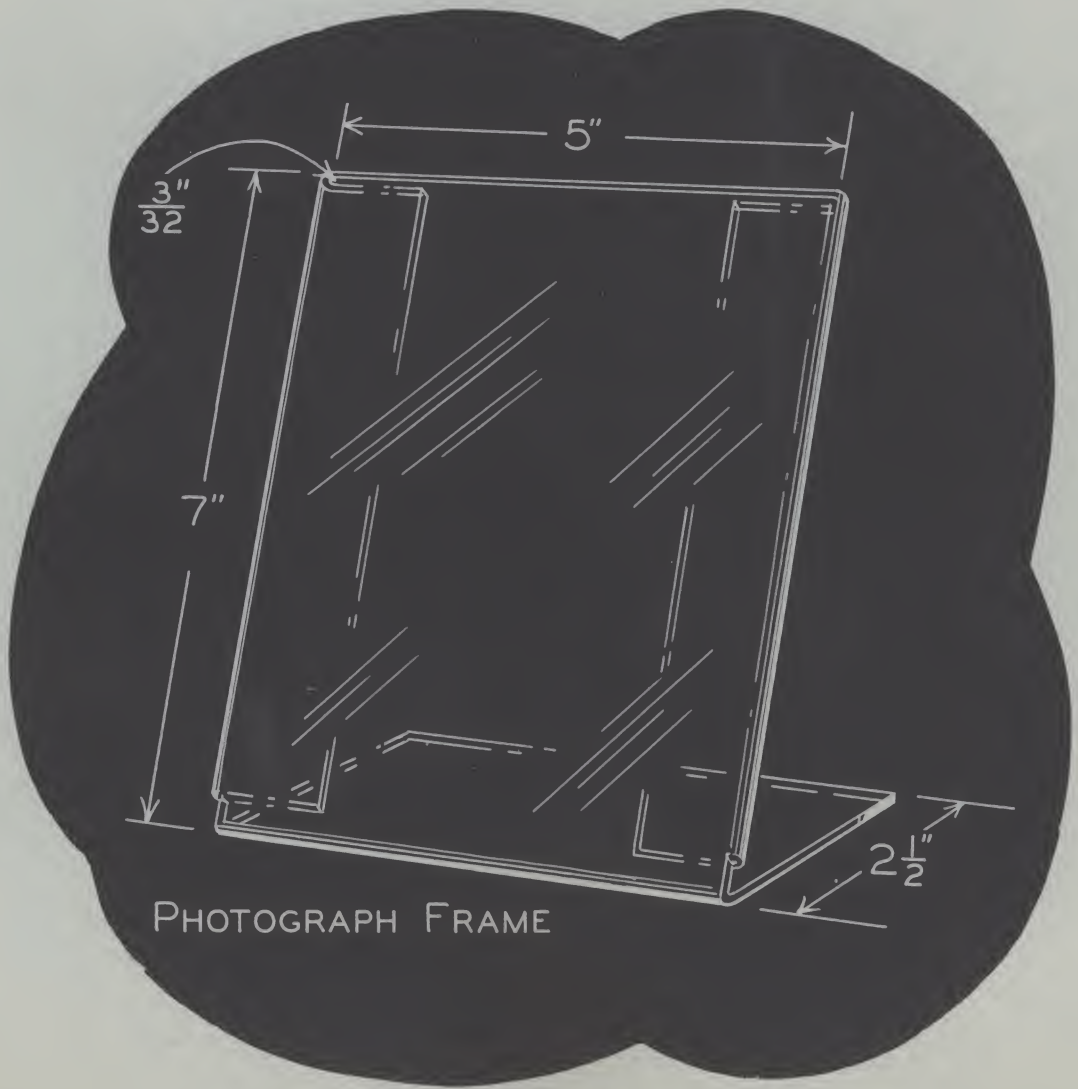
HAT AND COAT HOOK



DRAWER COMPARTMENTS



CORNER SHELF



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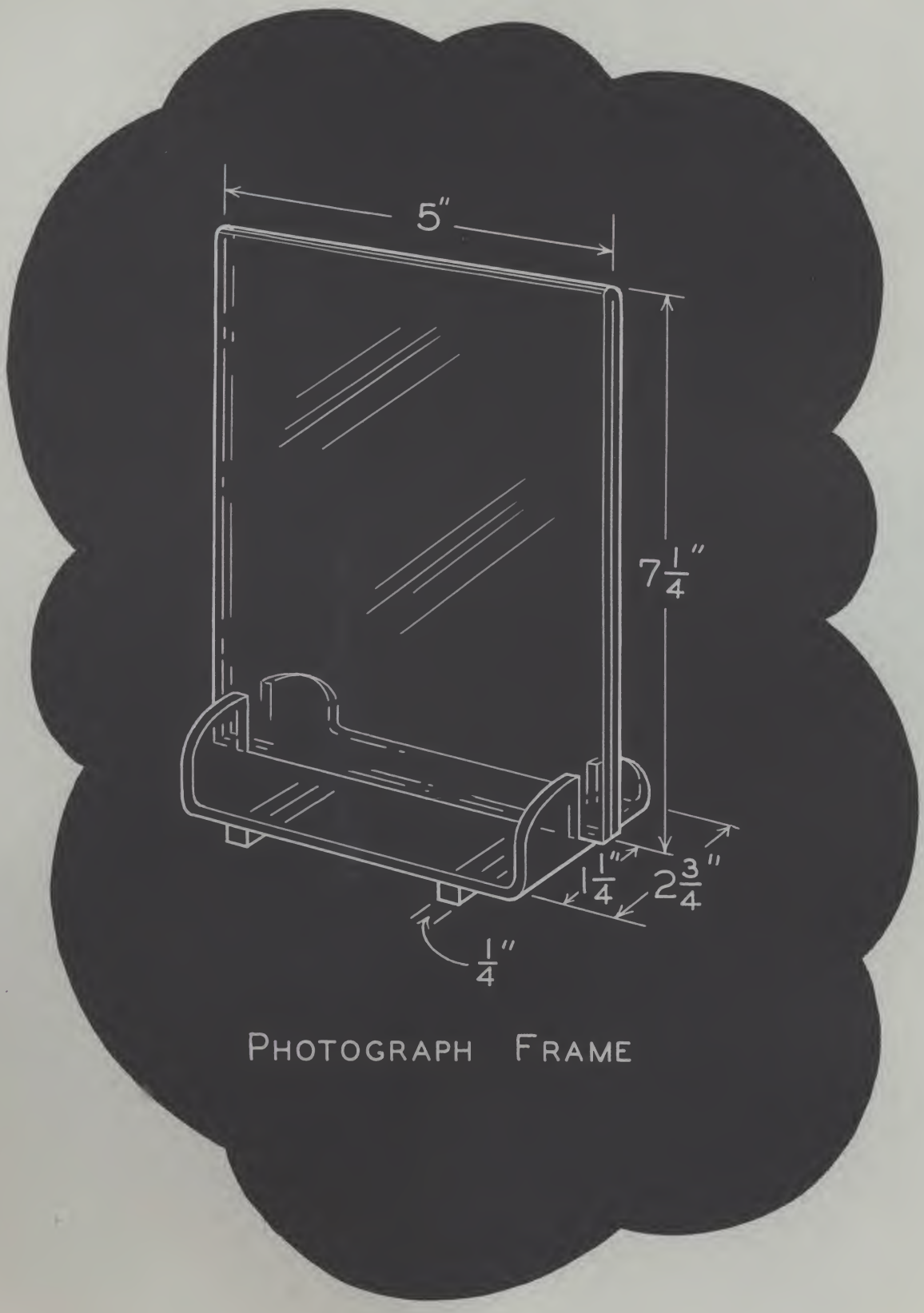

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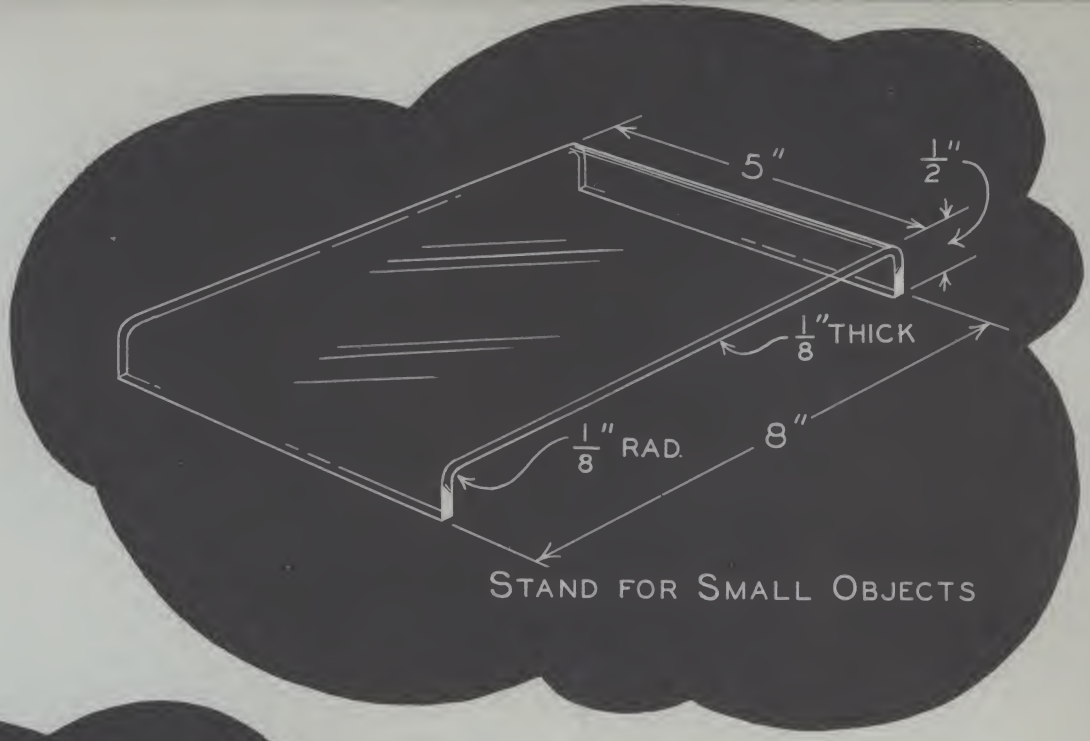
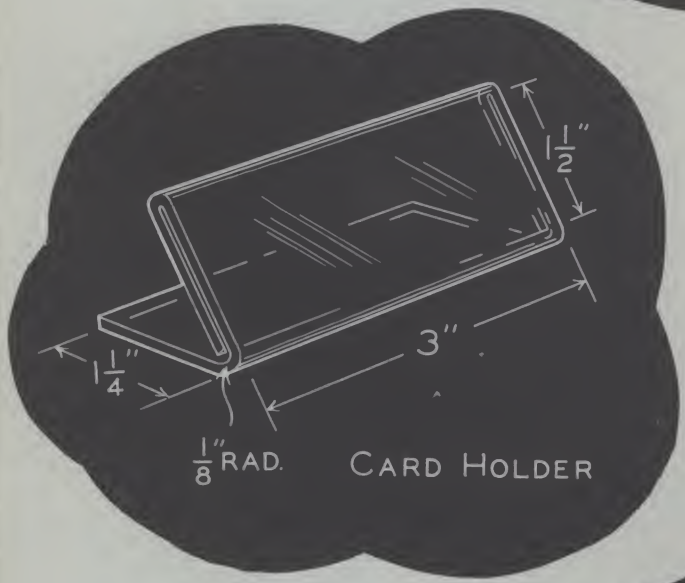
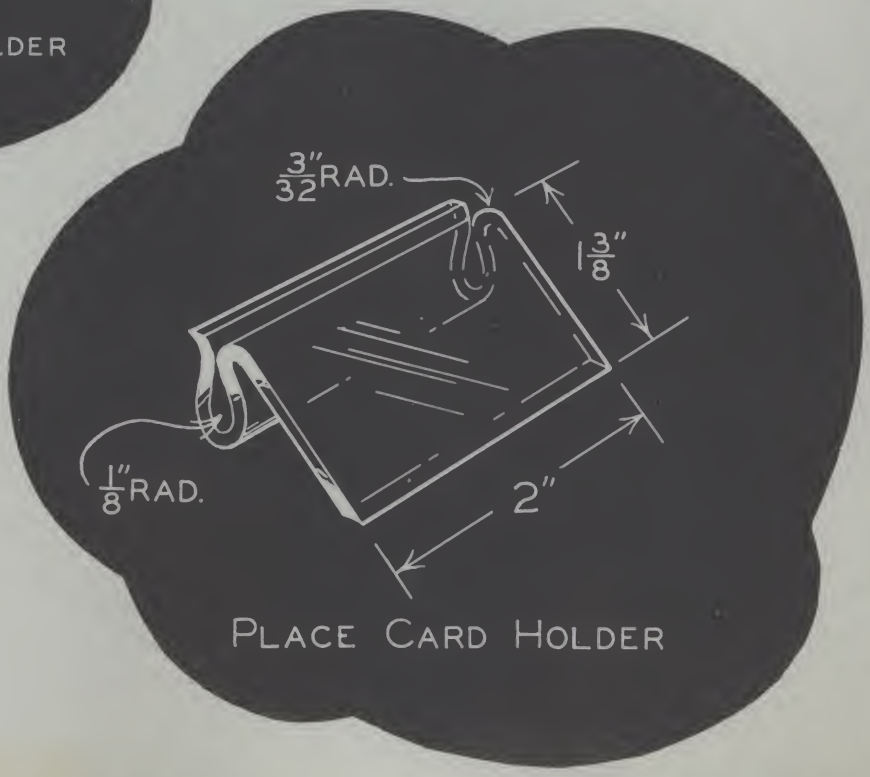


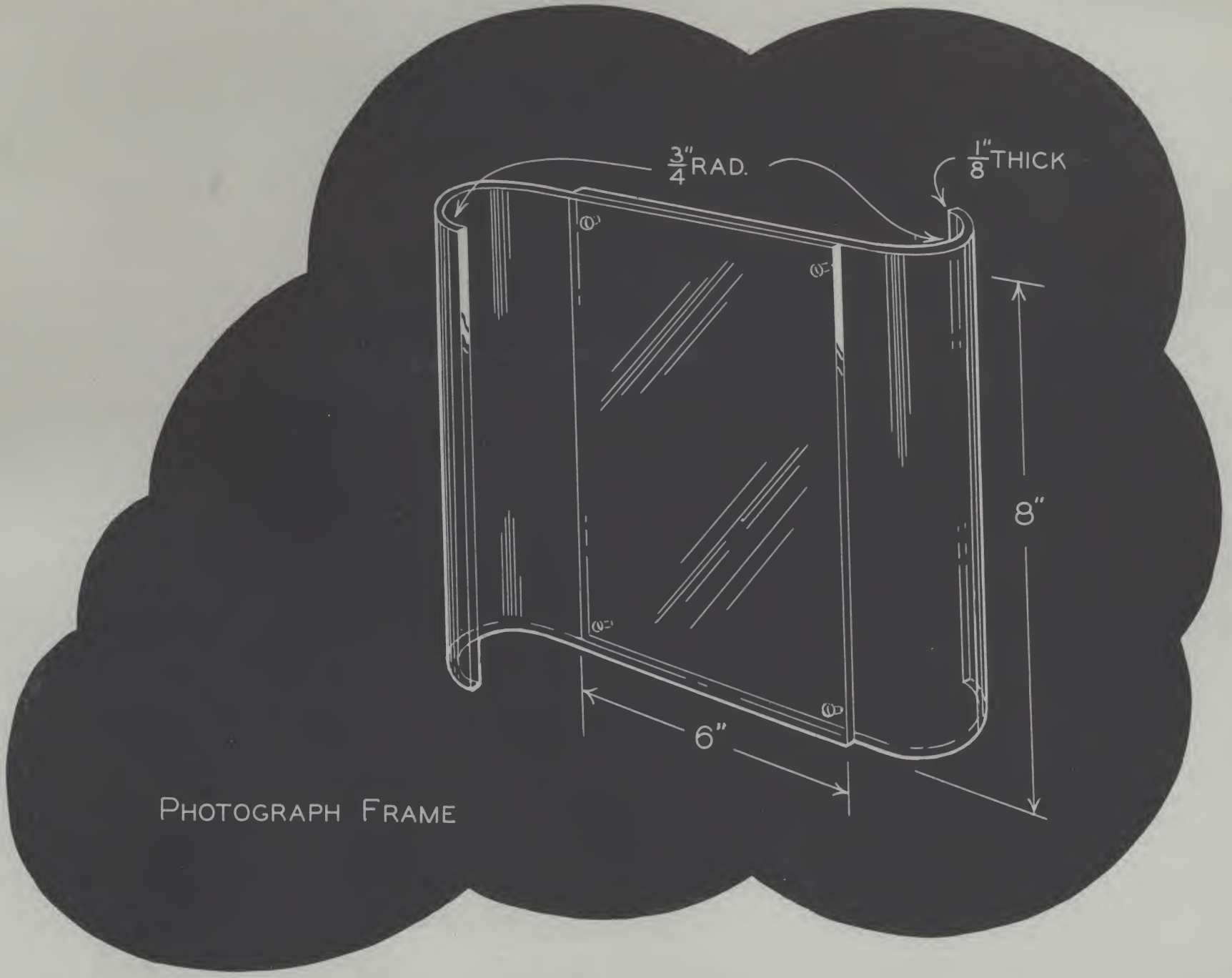
STAND FOR SMALL OBJECTS



CARD HOLDER



PLACE CARD HOLDER



PHOTOGRAPH FRAME

ONLY ROHM & HAAS MAKES PLEXIGLAS

PLEXIGLAS is manufactured by Rohm & Haas Company, pioneers and principal producers in the field of acrylic plastics. This book refers specifically to sheets and rods, since these are the forms in which school and home craftsmen will use the material. Plexiglas is also available in powdered form for compression and injection molding and extrusion.

PLEXIGLAS SHEET SPECIFICATIONS

Plexiglas is available to schools and hobbyists from dealers in principal cities throughout the country.

STOCK SIZES OF PLEXIGLAS SHEETS

Standard Thicknesses

Thickness	Standard Sizes	
.060"	36 x 48	18 x 36
.080"	6 x 12	18 x 60
.100"	12 x 12	20 x 50
.125"	12 x 18	40 x 50
.150"	12 x 24	24 x 24
.187"	12 x 36	24 x 36
.220"	12 x 48	24 x 48
.250"	36 x 60	24 x 60
.312"	12 x 60	30 x 36
.375"	18 x 18	36 x 36
.500"	18 x 24	

Larger Standard Sizes in Thicknesses from .100" to .500":

36 x 72	48 x 60	60 x 72
48 x 48	48 x 72	67 x 79
	53 x 80	

Also thicknesses .625" to 2.000" in 1/8" increments in these sizes:

6 x 12	12 x 36	24 x 24	30 x 48
12 x 12	12 x 48	24 x 36	36 x 36
12 x 24	20 x 50	24 x 48	40 x 50

COLORS—Red, Amber, Yellow, Green, Dark Green, Blue, White Translucent, Black

Your Dealer

MATERIALS, SUPPLIES AND EQUIPMENT FOR FABRICATING PLEXIGLAS

Listed below are the materials, supplies, and equipment, most of which have been actually used by our fabricating plants, and our sources of supply for these products. In many cases, the equipment is available from your Plexiglas dealer or mill supply houses. Your local supplier should be consulted before writing any of the sources given here.

CLEANING COMPOUNDS

Franklin's Plexiglas Cleaner
Vendor—Franklin Research Co., 5200 Lancaster Ave., Philadelphia, Pa.

Other commercial cleaners
Vendors—Etsol Synthetic Products, Detroit, Michigan
Lehigh Chemical Products, Ambler, Pa.
O. E. Linck, Montclair, New Jersey
Synco Products Co., Chattanooga, Tenn.
Tunco Products, Chicago, Ill.
Tunco Products, Los Angeles, Calif.
Zep Manufacturing Co., Atlanta, Georgia

POLISHING COMPOUNDS

Red—B7
Gray—4M-30
White—6M-157 (white rouge [finest])
Tallow—Emery wheel lubricant M.T.
Vendor—Hanson-Van Winkle-Munning Co., Matawan, New Jersey

Triple A Buffing Compound
Vendor—McAleer Manufacturing Co., P.O. Box 149, Rochester, Michigan

White Plascor #705
White Plascor #1403
White Rouge
Vendor—United Laboratories Company, Linden, New Jersey

BUFFS (SURFACING AND POLISHING)

Premier Atlas soft fancy buffs—20″ dia., 16 row radial sewing
Premier Atlas soft fancy buffs—10″ dia., 16 row radial sewing (ventilated)
Soft fancy cotton buffs—48-48
Hard cotton buffs—84-92
Jewelers cotton flannel buffs—10″ dia. 63 ply, 2 rows radial sewing
Vendor—Hanson-Van Winkle-Munning Co., Matawan, New Jersey

CLEANERS AND POLISHES

Aerogroom Cleaner
Vendor—Autogroom Company, Inc., 68-02 38th Ave., P.O. Box 4, Woodside, L. I., N. Y.

Franklin's Burnisher for Plastics
Vendor—Franklin Research Co., 5134 Lancaster Ave., Phila., Pa.

Ken-Glo
Vendor—Ken-nite Company, 2926 Hancock Ave., W., Detroit, Michigan

Lincoln M-3828 Liquid Cleaner
Vendor—Lincoln Motor Car Div., Ford Motor Co., Dearborn, Michigan

McAleer PLEX-I-GLO Cleaner & Polish
Vendor—McAleer Manufacturing Co., P.O. Box 149, Rochester, Michigan

Noxon Cleaner Polish
Vendor—Noxon, Inc., 94-02 104th St., Ozone Park, N. Y.

CLEANERS AND POLISHES

Continued

O'Cedar of Canada—M-37 Plastic Cleaner
Vendor—O'Cedar of Canada, 365 Sorauren Ave., Toronto 3, Ont., Canada

Parko Gloss Polish & Cleaner #4B-L
Vendor—Park Chemical Co., Military & Vancouver Aves., Detroit, Michigan

Puritan's Plasti-Kleen
Vendor—Puritan Chemical Co., Buffalo, N. Y.

Simoniz Liquid Kleener
Vendor—Simoniz Company, 2100 Indiana Ave., Chicago, Illinois

Turco L-567 Cleaner
Vendor—Turco Products, Inc., P.O. Box 2649, Terminal Annex, Los Angeles, California

Wilco Scratch Removing Compound #55 and #35
Vendor—Wilco Company, 6800 McKinley Ave., Los Angeles, Calif.

Starlite Con-Sol Glass Cleaner
Vendor—Consolidated Chemical Labs., Inc., S. Vandeventer at Hunt Ave., St. Louis, Mo.

Apex "Tk-10" Cleaning Compound
Vendor—Apex Alkali Products Co., Main & Rector Sts., Phila. 27, Pa.

Phenoid Cleaner & Polish
Vendor—Chalmers Chemical Co., 123 Chestnut St., Newark, New Jersey

#1140 Plasti-Color Liquid Polish
Vendor—Formax Mfg. Co., 3171 Bellevue, Detroit 7, Michigan

Tumbler Aviation Windshield Cleaner #50
Vendor—J. A. Tumbler Laboratories, 421-425 Hanover St., Baltimore 1, Md.

Sno-Flake Cleaning Compound
Vendor—Coronet, Inc., 2485 Beaufait Ave., Detroit 7, Michigan.

Whiz Mirror & Glass Finish
Vendor—R. M. Hollingshead Corp., Camden, New Jersey

WAXES

Duco #7 Wax
Vendor—E. I. Du Pont De Nemours & Co., Inc., Wilmington, Delaware

*Franklin's Anti-Static Wax for Plastics
Vendor—Franklin Research Co., 5134 Lancaster Ave., Phila., Pa.

Johnson's Industrial Wax 102-C
Vendor—S. C. Johnson & Son, Inc., Industrial Wax Div., Racine, Wisconsin

Parko Eze-Wax
Vendor—Park Chemical Co., Military & Vancouver Aves., Detroit, Mich.

Plasticlear Super Hard Wax
Vendor—L. W. Ferdinand & Co., Inc., Mica Lane, Newton Lower Falls 62, Mass.

*To avoid the accumulation of electrostatic charges—and the resultant accumulation of dirt—on Plexiglas surfaces, an anti-static wax has been developed. An application of this wax (Franklin's Anti-Static Wax for Plastics) is effective for long periods, but its anti-static properties are reduced by wiping with a wet cloth. If this wax is used, clean Plexiglas between washings by wiping lightly with a soft, clean, dry cloth. Apply anti-static wax after each washing.

WAXES *Continued*

Simoniz Wax
Vendor—Simoniz Company, 2100 Indiana Ave., Chicago, Illinois

Air-Flo Auto Polish
Vendor—R. M. Hollingshead Corp., Camden, New Jersey

Sno-Flake Wax-Coat
Vendor—Coronet, Inc., 2485 Beaufait Ave., Detroit 7, Michigan

3M Auto Wax
Vendor—Minnesota Mining & Mfg. Co., St. Paul, Minn.

Firestone Aircraft Window Cleaner
Vendor—Firestone Tire & Rubber Co., Aeronautical Div., Akron, Ohio

SANDING MATERIALS

Coarse dry belts for sanding edges:
Grits 1, 1½, 2, 2½—Aluminum oxide grit—elect. coated

Wet or dry belts for refinishing surface:
Grits 120, 150, 180, 240, 320, 400—TRI-M-ITE cloth

Wet or dry sanding paper for refinishing surface:
Grits 150C, 240A, 240C, 320A, 320C, 400A, 600A
Vendor—Minnesota Mining & Manufacturing Company, St. Paul, Minn.

SANDING EQUIPMENT

Craftsman sander—4 x 52 belt
Vendor—Sears, Roebuck & Co., Chicago, Illinois

Delta sander—6 x 44 belt
Vendor—Delta Manufacturing Co., Milwaukee, Wisconsin

Walker-Turner sander—6 x 48½ belt
Vendor—Walker-Turner, East Plainfield, New Jersey

Guild hand sander—2 x 21 belt
Vendor—Syracuse-Guild Tool Co., Syracuse, New York

FILES

Nicholson hand files—8″ and 10″

Nicholson half-round files—round files—8″ and 10″

Nicholson Swiss pattern files

Cut—bastard, second cut, smooth
Vendor—Maddock & Company, 42 N. Sixth St., Phila. 6, Pa.

CHINA MARKING PENCILS

Red—#169-T

Blue—#168-T
Vendor—Blaisdell Pencil Co., 141 Berkley St., Phila., Pa.

BAND SAWS

18′-0″ x ½″—10 pts.

114-¾″ x 5/16″—11 pts.

78″—3/16″ x ½″—8 pts.
Vendors—C. W. Marwedel, 1235 Mission St., San Francisco, Calif.
Walker-Turner Co., East Plainfield, New Jersey.
Delta Manufacturing Co., Milwaukee, Wisconsin

JIG SAW BLADES

#145—6″—15 teeth per inch

#620—6″—20 teeth per inch

#410—6″—10 teeth per inch

Vendors—C. W. Marwedel, 1235 Mission St., San Francisco, Calif.
Swanger Brothers, 134 N. Third St., Phila. 6, Pa.
Walker-Turner Co., East Plainfield, New Jersey

ROUTING EQUIPMENT

1 h.p. motor—R5A

Beading and fluting base—R5A

Plain router base—R5A

Template guide "L"

⅜ h.p. motor—R4

Beading and fluting base—R4

Plain router base—R4

Straight and circular gauge—R4

Template guide "B"

Shaper table—S4

Vendors—R. L. Carter Div., Stanley Works, New Britain, Conn.
Ekstrom, Carlson & Co., Rockford, Illinois
C. W. Marwedel, 1235 Mission St., San Francisco, Calif.
Swanger Brothers, 134 N. Third St., Phila. 6, Pa.
Delta Manufacturing Co., Milwaukee, Wisconsin

SHAPER CUTTERS

Straight face—3 wing
#SS54—⅝″ bore—1″ face

Molding Head
#RA225—¾″ bore

Straight faced knives for molding head
#RA225-1

Vendors—Swanger Brothers, 134 N. Third St., Phila. 6, Pa.
Walker-Turner Co., East Plainfield, New Jersey

DRILLS

Cleveland twist drills—H.S.S. ⅛″ to 1″ drills

Cleveland straight shank drill set #84 (#1 to #60) H.S.S.

Cleveland combined drills and countersinks

Cleveland straight fluted hand reamers

Cleveland counterbores with interchangeable pilots

Vendors—Maddock & Company, 42 N. Sixth St., Phila. 6, Pa.
C. W. Marwedel, 1235 Mission St., San Francisco, Calif.

PORTABLE ELECTRIC DRILLS

Black & Decker—HOLGUN

Black & Decker—1/2" Special

Vendors—Black & Decker Co., Towson, Maryland
Maddock & Company, 42 N. Sixth St., Phila. 6, Pa.
C. W. Marwedel, 1235 Mission St., San Francisco, Calif.

HAND GRINDING EQUIPMENT

Bits, grinders, saws, etc.

Vendors—Chicago Wheel & Mfg. Co., 100 S. Aberdeen St., Chicago, Ill.
Maddock & Co., 42 N. Sixth St., Phila. 6, Pa.
C. W. Marwedel, 1235 Mission St., San Francisco, Calif.
Fordham Electric Co.

Dunmore hand grinder #10—1/10 h.p.
Rubber cushioned arbors
abrasive bands

Vendors—Dunmore Company, 506 Fourteenth St., Racine, Wisconsin
W. B. Rapp Co., 132 N. Third St., Phila. 6, Pa.

Sanding drums and sleeves

Vendor—Walker-Turner Co., East Plainfield, New Jersey

CEMENTING TAPE

(Ask for special tapes for cementing PLEXIGLAS)

Vendors—Industrial Tape Corp., May Road, New Brunswick, New Jersey
Minnesota Mining & Manufacturing Co., St. Paul, Minn.
C. W. Marwedel, 1235 Mission St., San Francisco, Calif.

MOLD COVERING

Imitation chamois #709

Vendor—Miller, Bain & Beyer, 10th & Filbert Sts., Phila. 7, Pa.

Suede covered rubber

Vendors—National Automotive Fibres Co., 19925 Hoover Ave., Detroit, Mich.
Atlas Powder Company, Zapon Div., Stamford, Conn.

OVENS

Vendors—Harold E. Trent Co., Leverington Ave. & Wilde St., Phila. 24, Pa.
Lydon Brothers, 229 Colden St., Jersey City, New Jersey

CEMENTS

Ethylene Dichloride
Cement I-C
Methylene Dichloride

Vendor—Rohm & Haas Company, Washington Square, Phila. 5, Pa.

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